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JOURNAL

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AMERICAN WATER WORKS ASSOCIATION

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VOL. 7 MARCH, 1920 No 2

COMMENTS

TREATMENT TO COUNTERACT ALGAE GROWTHS IN LARGE RESERVOIRS

The minute plant growths that develop from time to time in waters that are exposed to the light represent a troublesome problem to the water works operator who is responsible for the palatability of the supply furnished to his community. The use of copper sulphate to destroy such growths is well recognized in the water supply art, but its application has, so far as the writer knows, been limited to comparatively small bodies of water, such as distribution reservoirs and relatively small collection and storage reservoirs, or else to the shallower areas of large reservoirs. The problem of destroying such growths in reservoirs holding many billions of gallons of water is one which it is believed has not been previously solved, and about which there are few or no data available. A description of some recent experiments in this line, undertaken in connection with the Catskill water supply of the city of New York will be briefly set forth, in the hope that such experience may be of some benefit to others, and may also bring forth other experiences which may be pertinent to this subject.

During the two years that the Catskill system has been utilized to supply about three-fifths of the total water consumed in the city of New York, there has been anxiety over the possibility of

microscopic algae growths simultaneously appearing in both the Ashokan and the Kensico reservoirs in sufficient numbers to noticeably and disagreeably affect the taste and odor of the water delivered to the consumer. Up to December, 1919, there had been no such simultaneous growth, although an uncomfortably narrow margin of time had separated in the past the dying out of a growth in one reservoir and the development of a growth in the other reservoir. Before the Catskill supply had been introduced, an unsuccessful experiment had been tried in the Croton aqueduct, by treating the waters from Croton lake with a solution of copper sulphate, to determine whether such treatment would destroy these growths, and it therefore appeared doubtful whether copper sulphate treatment could effectively be applied to water flowing through a long aqueduct.

In December conditions developed in the Catskill supply which made it necessary to do whatever seemed to offer even a remote chance of success in killing the algae growth. In the Kensico reservoir asterionella had developed in all parts of the reservoir to an extent of over 2000 units per cubic centimeter. In the Ashokan reservoir the growth of asterionella had reached in both basins an equal or greater number of units. This number of asterionella is sufficient to cause a disagreeable geranium taste and odor, which is most noticeable in the hot water. At this time ice was forming in the Kensico reservoir, and it was decided to treat that reservoir as quickly as possible with as much copper sulphate as could be gotten into solution.

The reservoir has an irregular shape, and there is a distance of about 3 miles between the point where the flow from Ashokan enters the reservoir and the point where the water is drawn out to be delivered to the city. The reservoir at this time was substantially full, and held above the aqueduct level about 29,000,000,000 gallons. It was estimated that if 6000 pounds of copper sulphate were used we could treat with a strength of about one part to five million in weight the waters in that portion of the reservoir which lay between the influx chamber and the efflux chamber, extending to a line approximately half way between the side of the reservoir on which both the influx and efflux chambers are located and the opposite side of the reservoir. This work was immediately undertaken but the rapid formation of ice stopped the work when approximately 5000 pounds of copper sulphate had been added. To

prevent further seeding of the reservoir with algae growth, and to still further reduce if possible the growth already in the reservoir, it was decided to experiment with treating the flow in the aqueduct by continuously introducing copper sulphate in the proportion of one part to five million by weight, the chemical to be introduced at the alum treatment plant, which is located about an hour's flow upstream from the influx chamber at the Kensico reservoir. A mechanical feeding device installed at this alum plant permitted a very close regulation of the rate of feed of the copper sulphate. The treatment was started, using about 625 pounds per twenty-four hours, the flow through the aqueduct being uniformly maintained at very close to 380,000,000 gallons daily. This treatment has now been continued for three weeks, and the results obtained are interesting, although not considered conclusive as yet.

The treatment of the water in the reservoir resulted in an irregular change in the number of units that appeared in the supply as drawn from the reservoir. This supply is passed through the aerator, and the sample taken after the water had passed through the aerator and through Hillview reservoir, which contains about three days' supply, showed that the organism had lost its virility, many of the units appearing to be mere shells, and almost no complaint has been registered on account of taste and odor from the organism, although frequently there have been as many as 2000 to 3000 units per cubic centimeter. The treatment of the flow through the aqueduct shows very little change in the number of organisms at the point where the water is discharged into the reservoir, but samples taken at points ½ mile apart and extending 2 miles down the reservoir, indicated that the growth has been substantially eliminated through this treatment. The appearance of the organism as it enters the reservoir also tends to corroborate the conclusion that the treatment has been effective.

In samples taken during the week ending January 17, 1920, the number of organisms at the point where water enters the reservoir was 1350; at a point ½ mile below the intake, 1400; 1 mile, 115; 1½ miles, 1925; 2 miles, 1825. These figures indicate that the treatment of the inflow to the reservoir has been felt for a distance of a mile from the influx chamber, this being about the distance that we would expect the flow from the aqueduct to extend during the three weeks' period of treatment.

The cost of this treatment is about $50 a day and is a negligible amount when it is divided by the number of million gallons treated, as the resultant cost per million gallons is about 13 cents.

The writer again requests that others who may have had experience with treatment of large bodies of water for the destruction of algae growths, will communicate with the Editor of the JOURNAL, setting forth such experience for the benefit of all interested.

WM. W. BRUSH.

IN UNION IS STRENGTH

One of the features of the Iowa Section of our Association is its interest in the larger problems of water works administration and the effect of state legislation on water supplies. At the recent meeting in Mason City, for instance, a legislative committee was appointed after a full discussion of desirable changes in the statutes relating to water works, to present these reforms to the Iowa Code Commission. This is a commission appointed by the last general assembly to revise the State Code by eliminating obsolete laws and harmonizing those which conflict more or less. The Commission is not to go into salaries or budget, it is understood, but solely into the revision of the statutes.

The sessions of this commission afford an unusual opportunity for improving the legislation affecting the work of the Iowa Section members and advantage is being taken of them. Already Messrs. Shoemaker, Carlin and McEvoy, with the writer, have appeared before the commission and other meetings will be held, it is expected. At the first meeting the following topics were presented informally:

1. A proposal to require the metering of all water supplied by municipally owned water plants to public buildings, parks, water fountains, bathing beaches, garbage dumps, disposal plants and other public users of water, with the provision that such water now commonly supplied without charge be paid for by the city at actual operation costs, excluding cost of extensions from the calculations. The charge for each year is to be based upon the actual cost of water during the preceding year.

2. A proposal to make mandatory the levying of a millage tax by the city council for the support of the municipal water plant upon receiving certification of necessity from the governing board of the plant.

3. A proposal to permit the assessment of real estate along the lines of proposed extensions of the mains of municipal water plants for the purpose of meeting the cost of laying such mains. Upon the property owner making connection to these mains and becoming an actual user of water, the amount of the assessment is to be returned to him according to a scheme to be devised. The assessment is to be calculated on the cost of laying 6-inch pipe and where a larger pipe is laid the difference is to come from the general funds of the plant.

4. A proposal to allow the board of trustees or other governing body of a municipal water plant to pension and retire at its discretion any employee who has been in the service of the plant for twenty-five years or more.

The members of the Iowa Section hold that it is their duty to leave untried no opportunity to place the water supplies of the state in a condition of unquestionable efficiency, with respect to quality, quantity and management. They are united in this policy and while they may not obtain all they ask at this time, their combined influence is unquestionably making an impression where the independent action of a few individuals would be less regarded. The fact that such united action is being taken, after full discussion, by a committee which is devoting itself whole-heartedly to its responsibilities, is worth mentioning in view of the occasional criticism made against water works men that it is impossible to get them to act collectively except in strictly technical matters.

JACK J. HINMAN, JR.

PROGRESS IN B. COLI TESTS

The paper by Captain Levine in this issue of the JOURNAL deserves the thoughtful attention of bacteriologists specializing in water analysis. There is a real necessity for developing a generally acceptable method of determining with fair reliability the presence of B. coli in water in a short time. The paper referred to is encouraging, like that by Dr. William Mansfield Clark in the JOURNAL two years ago. The suggestions are a step in the right direction, and as such are of distinct value to the bacteriologist and should be of interest to water works men as a class.

There is one point which a reading of the paper raises that is worth attention. This is the meaning to be attached to such terms

as "approximately correct" and the like. Captain Levine takes exception to a rather common practice among bacteriologists in interpreting the amount of gas formed by coli-like bacteria. He holds that in untreated water the rate of gas formation in lactose broth is of more importance than the amount of gas formed. If 10 per cent or more gas forms in 24 hours he holds that this is a reliable indication of the probable presence of B. coli, because this indication was confirmed in 97.7 per cent of his tests. However, out of the 193 samples classed as "moderate" in his table 1, a group developing less than 10 per cent of gas in twenty-four hours, 91.2 per cent were confirmed as B. coli, which a good many persons will be inclined to regard as "approximately" as good a ratio as 97.7 for some purposes. Even in the case of the 276 samples classified as "slow," a group developing no gas in twenty-four hours but 10 per cent or more in forty-eight hours, there were 202 samples or 73.2 per cent confirmed. That, also, is a fairly high ratio from some viewpoints.

There is evidently some relation between the rapidity of gas formation and the presence of B. coli in untreated waters. It is a subject that deserves to be investigated thoroughly as quickly as practicable in a number of laboratories. Until such comprehensive investigations have been made the writer is reluctant to draw very definite conclusions from the interesting and valuable results given in the paper under consideration. It is also apparent from these results that the rapidity of gas formation in the case of chlorinated waters may bear some relation to the presence of B. coli, for the percentage of tubes confirmed decreases as the rapidity of gas formation decreases.

The remarks in the paper about the relatively smaller importance of B. aerogenes in comparison with B. coli bear out the testimony of others who have lately been studying this family of bacteria. Captain Levine points out that the observations hold "particularly when considering stored and chlorinated waters." His reasons for rating a ground water as suspicious which contains B. aerogenes seem logical.

The use of the simplified eosine-methylene-blue-agar is very interesting and the results obtained with wider use of it will be of value. The promise of an acceptable method of rapid differentiation of B. coli and B. aerogenes which it offers is gratifying.

GEO. A. JOHNSON.

LIFE OF CAST IRON PIPE IN PHILADELPHIA

The report of the Committee on Depreciation[1] states that large cast iron pipe, kept clean and well maintained, has a life based upon "the possible changes in public need, functional usefulness and the burden of a reasonable amortization," and it suggests from seventy-five to one hundred and twenty-five years as a suitable range to adopt provisionally. In the case of small cast iron pipe a range of thirty to seventy years is suggested because of the increased difficulty in cleaning and maintaining small pipe, their removal on account of insufficient capacity for increased needs or the necessity of reinforcing them with additional pipe lines for the same reason. The experience in Philadelphia confirms these opinions and throws some light on early experience in using cast iron pipe which is interesting historically. Nothing has yet occurred to indicate that under normal conditions a limit can be placed upon the useful life of cast iron pipe in this city.

The first cast iron water pipe in Philadelphia was laid in 1817. It was flange pipe, imported from England. It was in continuous service until 1914, a period of ninety-seven years, when it was replaced by larger pipes in anticipation of street repavement. It was in good condition when taken up and had evidently by no means approached the limit of its useful life, except through obsolescence. Soon after it was laid a transition from flange to bell-and-spigot pipe occurred which is discussed in some reports of that time as follows:

> In their last report the Committee stated that they had written to London for information and had ordered a parcel of various size pipes fitted in a manner which experience had pointed out as best, and they have through the diligence and care of an engineer of the first respectability obtained some very useful information contained in two reports herewith submitted, and a number of pipes constructed upon such principles as will insure strength and prevent leaks at joints, and the Committee are decidedly of the opinion that they can be laid down at first cost at as low a price per foot as wooden pipes of the same diameter. (Report of Watering Committee, November 11, 1818.)
>
> Under every consideration perhaps it is well that the fourteen-inch iron main had not been put down as the experienced deficiency of water proved that it would have been too small, its area being 153 inches and rather less than the six ranges of wooden pipes now laid; and the method at that time in use of putting iron pipes together with flanch joints would in all probability have defeated the object by the leakage in that sort of pipes. The same incon-

[1] JOURNAL, March, 1919, page 103.

venience under which we now labor took place at the New River Water Works in London; and although they had fifty mains of seven-inch bore, still for want of a sufficiency of water they were compelled to abandon them and substitute large iron mains some of which were thirty inches diameter; they are cast with the common spigot and fauset joints. (Report to the Watering Committee late in 1818 by Frederic Graff, Superintendent of the Water Works, who later became the fifteenth president of the American Society of Civil Engineers.)

Five years later there was considerable criticism of the Committee for using imported pipe and it issued a statement to the effect that the greater part of the pipe already laid or on hand was made in the United States and none was imported when supplies could be obtained here except as samples for the benefit of American manufacturers. In 1823 the Committee reported the following details of the pipe and its use:

The straight pipes are made in lengths of nine feet with what are called spigot and faucet joints; other pipes of a circular form, to pass round corners, are made of different lengths, as may be required, with easy turns, by which it is obvious the passage of water is much facilitated.

The laying of the pipes is very easy, care being taken to keep them firm in their bed—the hub, or large end of one, laps about 4 to 6 inches over the small end of the other, leaving a space of from ¼ to ½ inch all around, which is first caulked in with a ring of plaited hemp to prevent the lead running into the pipes; then a pair of nippers with a joint in the lower part, to fit all around the pipes, and having an opening on top for the lead, and another for the escape of the air, is affixed next to the opening on the outer part of the pipe, so as to prevent the lead coming out in front, which is further secured by a ring of clay, outside of the nippers, and formed into a cap at top, into which melted lead is poured, forming a ring of lead 3 or 4 inches in depth. When the lead is cold the clay and nippers are removed and it is then upset with a hammer and chisel, which completes the joint.

A line of this old pipe which was laid in 1827 was removed in 1915 during subway construction. It was in excellent condition after eighty-eight years of service but was not relaid because a main of larger capacity was desirable. Several hundred feet of 30 inch pipe laid in 1850 were taken up during 1918 to facilitate parkway construction and found to be in such satisfactory condition that after being cleaned they were relaid.

CARLETON E. DAVIS.

STANDARDIZATION OF CHEMICALS USED IN ANALYTICAL WORK

The attention of chemists engaged in water analysis is called to the formation by the American Chemical Society of a committee to standardize the specifications for reagents used in the laboratory. The chief complaints about these reagents relate rather to lack of reliability of the analyses than to unsatisfactory quality of the materials themselves, although there are many cases of impurities causing dissatisfaction which could have been removed by the exercise of more care in their preparation. Insufficient knowledge on the part of the producer as to requirements and acceptable methods of testing has been one cause of dissatisfaction, and some makers have signified their willingness to follow standard specifications and methods of testing. The conditions found by the Bureau of Chemistry of the United States Department of Agriculture during the last four years, when about 1,300 shipments of chemicals from many dealers and manufacturers were tested, are as follows:

Most of the chemicals are satisfactory although occasional impurities are found in chemicals from practically all manufacturers; it is necessary to test all shipments. The standard acids, ammonia, alkali salts and alkali, and most organic solvents are generally satisfactory. The soluble salts other than alkali salts are generally acceptable but seldom of a high degree of purity. Certain organic solvents and solids are either unobtainable or unsatisfactory. The insoluble products are generally unfit for use in analytical work.

Water chemists who desire to submit standard specifications for reagents for the Committee's consideration are requested to communicate with its secretary, W. D. Collins, Bureau of Chemistry, Department of Agriculture, Washington, D. C. Water supply chemists will undoubtedly second any attempt to secure standardization and reliability of the goods sold. Standardization can be secured and specifications can be written with comparative ease, but the writer has mental reservations about the practicability of securing at an early date any guarantee of the truthfulness of what is printed on the label. In the museum of the Rensselaer Polytechnic Institute there are some odd instances of the short-comings of one of the best and most trusted houses supplying chemicals of high grade to American laboratories. One bottle is labeled "Oleic Acid;" it contains oxalic acid. A second labeled "One Pound Boric Acid" really contains boric acid—together with a boulder of silica nearly

the size of an egg. The third curiosity is a 1-ounce bottle filled with phosphorus penta sulphide; it is labeled "5 lbs. Calcium Carbonate." What a strain on the bottle!

Now, what is the remedy? There are those who believe good may come from publishing the names of such concerns as are responsible for errors like those mentioned, but the employee is the one directly at fault and he cannot be always watched. We must not require too much and thus become impracticable. What person eating soup at dinner can be certain as to what did or did not happen to it before it reached him? Let us have standards by all means, and have hope that the manufacturers will live up to them, but let us keep an open eye ourselves, just as of yore.

W. P. Mason.

FLUSHING WATER MAINS

One of the features of maintenance work about which practically nothing has been printed is flushing water mains. There are so many opportunities for unusual and interesting incidents to occur in such work that it seems to be time to call for an account of them. Collectively, they should prove instructive reading. No matter how good the water is, mains must be flushed sooner or later, to get rid of mud, or iron, or organic matter. Possibly the nature of the contamination which makes flushing necessary will have some influence on the method of conducting the work most successfully. The general method adopted in Muscatine is as follows:

A section of a main from a few blocks to half a mile long is shut off by gates at the ends and side streets. If there is a flush gate on the section, it is opened and the main flushed out through it. If there is no gate, then the hydrants are opened, beginning with that at the highest elevation, or source of supply if a reservoir is used, and working downward, hydrant by hydrant. When the mains have been flushed, the cross-mains are cleaned out similarly. Although the work in the outlying districts is done during the day, most city flushing is best conducted in the night time so as to cause as little inconvenience as possible.

Our experience indicates that it is necessary to have a good force of men on the job, in order to be able to open the gates promptly in case of fire. The damage done by a bad fire is so much greater than the few dollars in wages for the men required to turn on water

promptly when it is needed, that there is no good excuse for the slowness in restoring normal conditions when an alarm is sounded. Another thing we have learned to be careful about is blowing off a flush gate at a greater rate than the sewer will receive the water. Damages by flooded cellars, due to water backing up through a sewer, are to be avoided. Not only are the parties injured subject to needless inconvenience, but the water department is criticised in a way that raises blisters. Where a main is 16 inches or more in diameter, it is necessary to have a number of hydrants open simultaneously to do the flushing well, and in such cases attention must be paid to the effect of the water on the street pavements. Under some conditions pavements and gutters might be injured badly if precautions against it were not taken in advance. Finally, our experience with flushing indicates that where considerable deposit must be washed out there is likely to be some clogging of meters after the work is done.

This is an outline of our methods. We have developed them through a long period until they meet our local needs. But there may be other methods which will please us better, and therefore the writer hopes that superintendents will write to the editor of the JOURNAL about them, in order that all members may have the benefit of the information. Anybody who has tried to find printed information on flushing does not need to be told that technical literature is practically silent on the subject.

WILLIAM MOLIS.

SCIENTIFIC CONTROL OF WATER SUPPLIES

At a recent gathering of public officials there was a fairly general agreement that technical matters could not be made of popular interest. The writer does not agree with this view and these notes are offered in support of his opinion.

The conspicuous features of a water-works system, the imposing dams, busy pumping stations and lofty water towers, draw public attention to the need of engineering talent in connection with such public works. The enormous retail business conducted by a water department or company, the most important business in a city, of which everyone is a customer, is gradually coming to be recognized by intelligent citizens as something that should be intrusted only to able business men. But there is practically no public appreci-

ation as yet of the need of safeguarding the quality of water by proper laboratory tests and the enforcement of suitable sanitary regulations. Only when an epidemic of typhoid fever or dysentery calls attention to the danger of neglect of sanitation is any thought given to the subject or any willingness shown to appropriate the small sums needed for sanitary supervision of the supply.

This is not surprising when all the facts are considered. The average man or woman is apprehensive only of a tangible danger in the water, something he or she can sense. An odor will cause protests; unusual tastes will cause strong complaints. But neither the protests nor complaints equal the uproar caused in the Atlantic seaside resorts a few summers ago by the presence of a few sharks. They were not the huge man-eaters of the tropical seas but fish rarely over 8 feet long. They killed a few persons, a very few, yet everybody was scared because from early childhood the ferocity of the shark has been common knowledge. Yet the shark is as harmless as a cooing dove compared with a little plant which kills its thousands annually in our American cities without any real public appreciation of its dangerous character. This plant is so small that it is measured in microns or thousandths of a millimeter. It would take about a million of them placed end to end to approximate the length of an 8-foot shark of the kind that caused would-be sea-bathers to content themselves with tubs a few years ago, yet each one of these million little plants is as dangerous to human life as a shark.

This little plant, the Bacillus typhosus, is so very minute that it is practically incomprehensible to the average man. When he is told that he must spend money to protect the water he drinks from infection by them he is inclined to class the advice as good—but not to be followed just now. But let a few dog fish show their triangular fins in the bay where he bathes on hot summer days, and immediate action is vociferously demanded. If he really knew the relative danger of the two sources of peril, he would urge his friends to help him secure adequate sanitary control of the water supply at once, and let the shark scare bother others.

Fortunately the large cities are beginning to realize the danger of Bacillus typhosus to the community. They are becoming cognizant of the help that science can give in checking and often in preventing unpleasant odors and tastes in water. Water works managers are learning that the laboratory is often able to point out possibilities of saving sums of money which sometimes amount to a

large proportion of the expense of such scientific assistance. Properly taught, through suitable publicity, the value of good continuous sanitary control of water is of real help in dealing with critical consumers. These advantages may be shown by referring briefly to what New York City is doing in safeguarding its water supplies, a subject discussed in detail in a paper presented on May 28, 1919, by Dr. Frank E. Hale before the Municipal Engineers of the City of New York, from which the following information has been obtained.

The Croton watershed is divided into 24 districts, with a sanitary inspector in each, making a daily patrol to see that no insanitary condition exists. There are five such districts in the Bronx and Byram watershed, seven in the Esopus watershed, and the Brooklyn watershed, when water is drawn from it, is put under a daily patrol system of inspection. Tap water samples in Manhattan and Brooklyn, samples from Ashokan reservoir and from a few points along the Catskill aqueduct are subject to daily bacterial and chemical examinations, as is the effluent from one of the sewage treatment plants on one of the watersheds. Other sources of supply are tested less frequently at present. Partial chemical analyses are made monthly upon all supplies, but complete chemical analyses are made weekly upon only a few representative samples. Microscopical examinations are made twice a month on the Croton reservoir and weekly on the distribution reservoirs. Other tests are made whenever needed; the supplies furnished by private water companies are analyzed monthly.

This laboratory control and the research work carried along with it enables the Department of Water Supply to furnish the best water which the existing works are capable of delivering. The advantages of storage in improving the quality of water are utilized to the utmost, and aeration of stored water is practised on a scale probably unknown elsewhere. Coagulation of the Catskill water has been investigated and whenever the regularly conducted tests show it is desirable as a working measure to improve the quality of this supply the treatment can be begun. All surface water used in New York is chlorinated before delivery to the consumer, sometimes more than once, and the chlorination is kept under constant supervision. Filtration of a very small part of the supply and the removal of iron from other small parts are watched carefully, and the operation of all stages of the processes at six sewage treatment plants

on the various watersheds is kept under constant supervision by frequent analyses. As a result of the better supervision of public sanitation generally and with these sanitary precautions the number of typhoid fever cases decreased in the period 1912–1918 as follows: Manhattan, 1389 to 554; The Bronx, 281 to 141; Brooklyn, 1358 to 453; Queens, 340 to 75; Richmond, 46 to 15. The typhoid death rate decreased during the same period as follows: Manhattan, 7.9 to 3.1; The Bronx, 4.9 to 2.6; Brooklyn, 13 to 4.0; Queens, 14.4 to 2.3; Greater New York as a whole, 9.6 to 3.3. The death rate figures in Richmond are erratic, ranging from 8.2 in 1916 to 2.2 in 1912; the 1918 rate was 5.9.

Mention has already been made of odors and tastes in water. These are investigated by the scientific staff and a great deal of practically applicable information has been obtained. Some of the trouble is due to dead ends but generally it is caused by micro-organisms. When these microörganisms are the cause, the trouble is generally foreseen and many complaints prevented. These microörganisms are minute plant and animal growths which have no known effect on the health of the consumer. Their presence is not usually noticeable until several thousand exist in every teaspoonful of water. Some of the reservoirs where these organisms develop can be by-passed, sometimes water of satisfactory quality can be drawn from some levels while that from other levels is affected. Aeration helps sometimes. Treatment with copper sulphate is a preventive in many cases but two or three days time must elapse before the water so treated is used. The one thing that experience to date has shown is that a new problem may be expected at any time during the season of growth of these organisms.

The help of the chemist and bacteriologist is essential in supplying water of really good quality to many cities. Year by year the laws governing the quality of water which may be supplied for drinking purposes are becoming more strict. Some states already make the supply of infected water a very serious matter for the officials of a water department.

JOHN M. GOODELL.

METHOD OF METERING THE WATER SUPPLIED TO THE FIVE DISTRIBUTION SYSTEMS OF THE CITY OF NEWARK, N. J.

By George Sanzenbacher[1]

There has recently been completed at Newark, N. J., a unique structure, figure 1, serving the dual purpose of a memorial to one of the city's most efficient former officials and a shelter for the apparatus which keeps a continuous automatic record of the quantity of water supplied to each of the five service districts.

The supply for the city comes from impounding reservoirs on the Pequannock watershed about 25 miles to the northwest. The original works furnished this supply through a 48-inch and a 42-inch riveted steel conduit, connected with two distributing reservoirs in the city, called the Belleville and South Orange Avenue reservoirs. About fifteen years ago the city built a storage reservoir holding 700,000,000 gallons at Cedar Grove, 7 miles from the city, in order to have a supply near at hand in case an accident happened to the riveted steel conduits. This reservoir is supplied through a 60-inch riveted steel conduit which is connected with the 42-inch and 48-inch conduits at Great Notch, a little less than a mile from Cedar Grove. From this storage reservoir a 60-inch riveted steel conduit was laid to the city. There is a Venturi meter on both the 42-inch and 48-inch conduits in the Pequannock watershed and one on the 60-inch conduit at Cedar Grove. Until the gauging devices described in this article were put in service, these three Venturi meters gave all the information that was available concerning the total quantity of water supplied to the city and the surrounding districts obtaining supplies from Newark.

The connections at Great Notch and Cedar Grove are so arranged that all of the supply for the city may be sent through the storage reservoir, which is the usual operating condition, or part may go to the reservoir and part to the city, or the water sent to the reservoir

[1] Engineer and Superintendent, Department of Water, Newark, N. J.

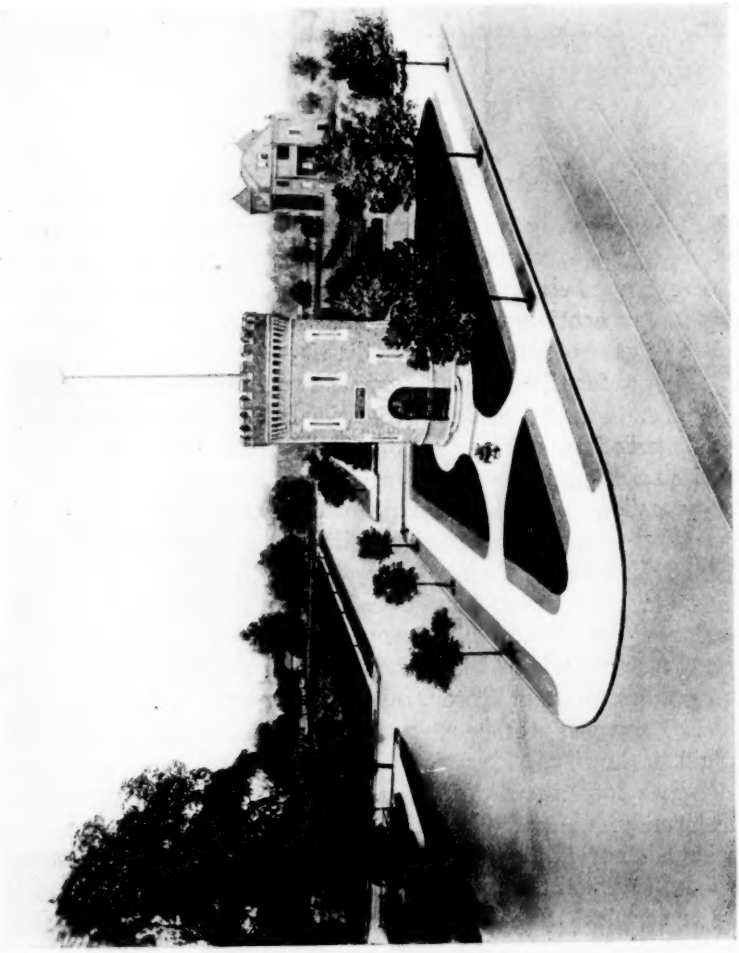


FIG. 1. MEMORIAL TOWER AND METER STATION, NEWARK WATER WORKS

may be by-passed there into the 60-inch conduit without going into storage.

Under the usual operating conditions, the supply for the entire city passes through the 60-inch conduit to the intersection of Bloomfield Avenue and North Sixth Street, at the point marked "Tower" in figure 3 and shown in detail in figure 2. Here there is a multiple header connection with a 36-inch cast iron main supplying a small district numbered 5 on figure 3 and called locally the Silver Lake district, a header connection to a 36-inch cast iron main supplying

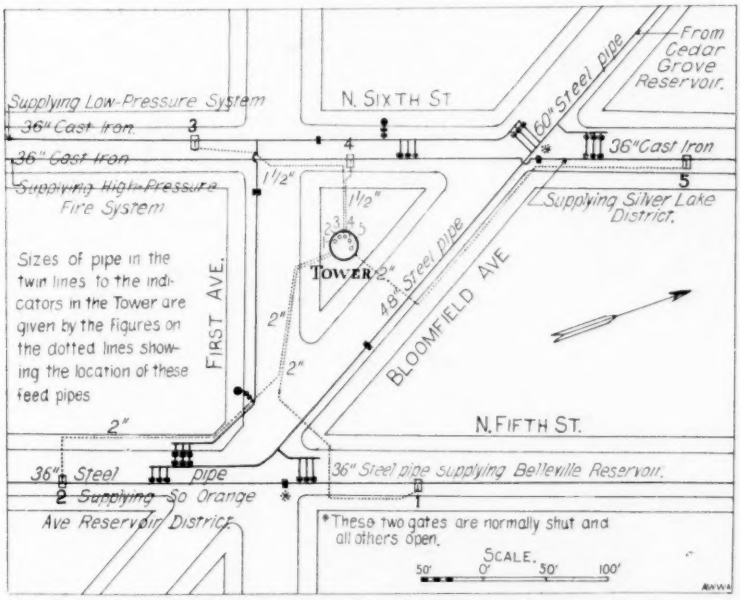

From Cedar Grove Reservoir.
60" Steel pipe
N. SIXTH ST
Supplying Low-Pressure System
36" Cast Iron
36" Cast Iron
Supplying High-Pressure Fire System
36" Cast Iron
Supplying Silver Lake District.
1½"
1½"
Sizes of pipe in the twin lines to the indicators in the Tower are given by the figures on the dotted lines showing the location of these feed pipes
TOWER
48" Steel pipe
FIRST AVE.
BLOOMFIELD AVE
2"
2"
2"
N. FIFTH ST.
36" Steel pipe
36" Steel pipe supplying Belleville Reservoir.
Supplying So Orange Ave Reservoir District
*These two gates are normally shut and all others open.
SCALE.
50' 0' 50' 100'

FIG. 2. PIPE CONNECTIONS AT THE TOWER

part of district 3, and a header connection with a 36-inch cast iron main supplying the high service district marked 4 on figure 3. The 60-inch steel main changes to a 48-inch riveted steel main which continues through Bloomfield Avenue to North Fifth Street. Here there is a header connection with a 36-inch riveted steel main to the Belleville reservoir supplying parts of the districts marked 1 and 3 on figure 3, a header connection to a 36-inch riveted steel pipe to the South Orange Avenue Reservoir supplying district 2 and part of district 1. The arrangement of multiple headers and gates is such

that each 36-inch main can be supplied through either or both of two headers.

The high pressure district of the city, the stippled area marked 4 in figure 3, has an independent system of distribution mains. It

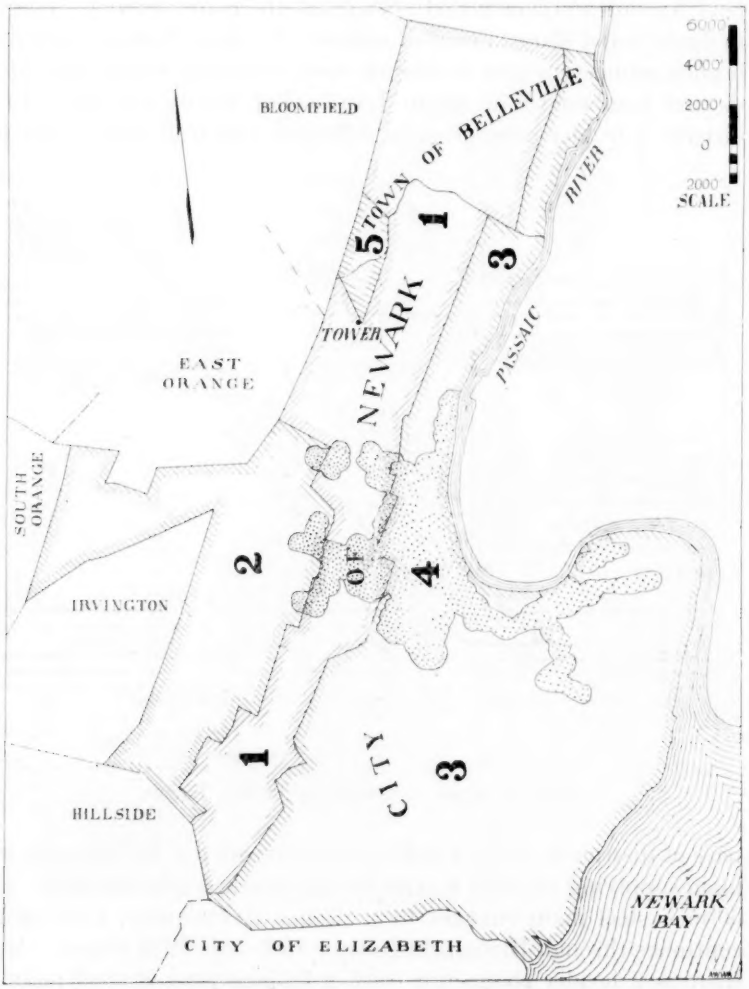


FIG. 3. SERVICE DISTRICTS OF THE NEWARK WATER WORKS

was installed for fire protection exclusively and a large part of the piping consists of heavy 20 and 12-inch cast iron mains with double-leaded joints. This system furnishes a limited amount of water for the upper floors of high buildings and a few hydraulic elevators,

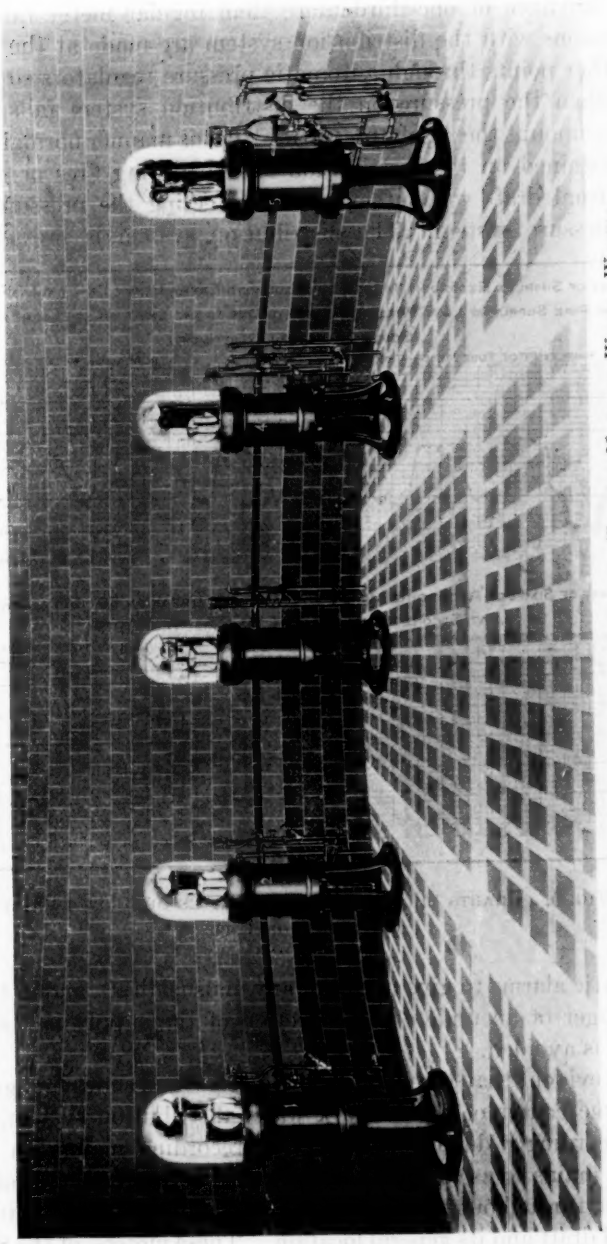


FIG. 4. METER RECORDERS IN THE MEMORIAL TOWER, NEWARK WATER WORKS

at an advance of one-third more than regular meter rates. The connections with the distribution system are made at the city hall and other points through automatic pressure regulators so designed that when the pressure on the distribution system falls below a certain amount the regulators open. In this manner normal pressure is maintained on the distribution system during fires or occasions of unusual draft without materially affecting the pressure on the high-pressure system. The distribution system is provided with

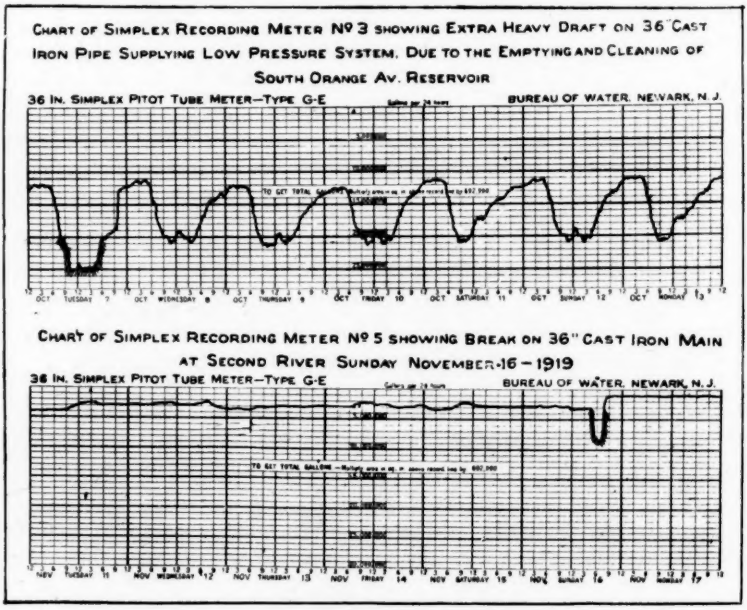


CHART OF SIMPLEX RECORDING METER Nº 3 SHOWING EXTRA HEAVY DRAFT ON 36" CAST IRON PIPE SUPPLYING LOW PRESSURE SYSTEM, DUE TO THE EMPTYING AND CLEANING OF SOUTH ORANGE AV. RESERVOIR
36 IN. SIMPLEX PITOT TUBE METER—TYPE G-E
BUREAU OF WATER, NEWARK, N. J.
CHART OF SIMPLEX RECORDING METER Nº 5 SHOWING BREAK ON 36" CAST IRON MAIN AT SECOND RIVER SUNDAY NOVEMBER 16 – 1919
36 IN. SIMPLEX PITOT TUBE METER—TYPE G-E
BUREAU OF WATER, NEWARK, N. J.

FIG. 5.—CHARTS SHOWING UNUSUAL RATES OF FLOW IN MAIN DISTRIBUTION PIPES

automatic alarms to give notice of any unusual draft, and in this way the danger of an undetected depletion of the supply in the entire system is avoided.

It is evident that the little triangle of ground shown in figure 2 is the nerve center of the Newark water distribution system, and it was accordingly determined to place recording meters on all the 36-inch mains so as to obtain a permanent record of the wholesaling of water throughout the city and possess a means of detecting any unusual draft and its general location. These meters, of the Simplex

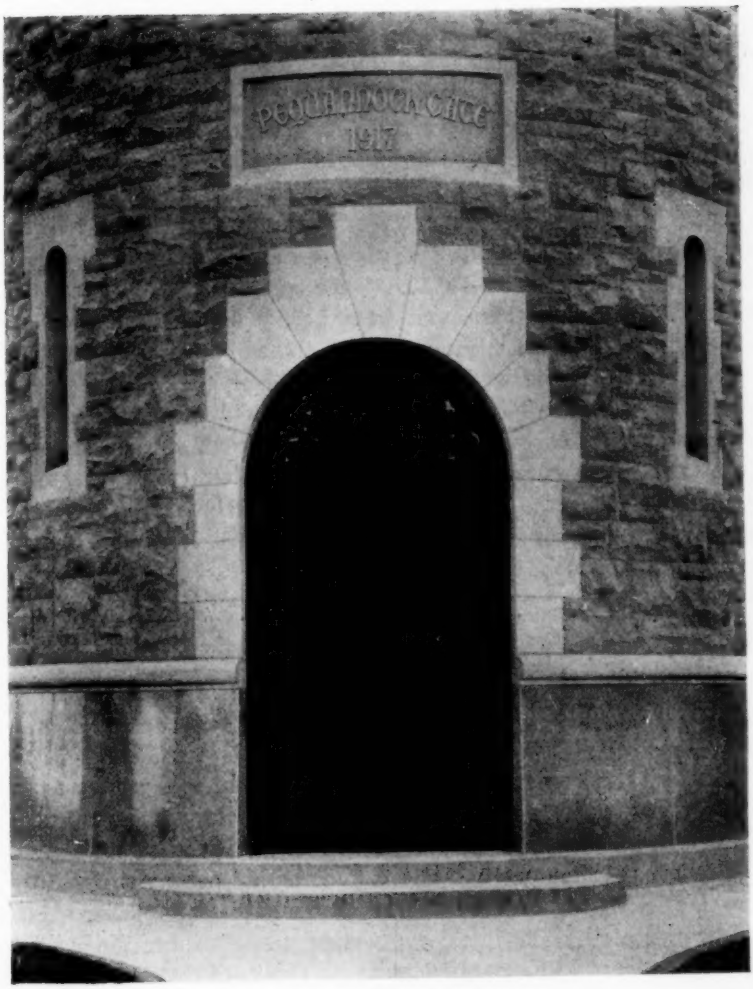


FIG. 6. HAYNES MEMORIAL DOORWAY

type, have been installed at the points shown in figure 2 and connected with the recording apparatus set up on the ground floor of the tower, figure 4. The meters have been in use but a few weeks, but it has already been found that they check the Venturi meter at Cedar Grove within a small fraction of 1 per cent.

The usefulness of this automatic record was shown a few days after it was placed in operation, as shown in the upper chart of figure 5. This was a case of heavy draft on the low-pressure system while the South Orange Avenue reservoir was emptied for cleaning.

Another interesting chart shows what happened when a break occurred on the 36-inch cast iron main in Belleville, north side of Second River, on November 15. Since this break was repaired, the diagram shows that there must have been a leak at that point for some time. In future such leak may be detected from the charts.

It was said at the beginning of these notes that the tower also served as a memorial to a prominent official of Newark. This was made possible by the location of the tower on a plot which gave an opportunity for building an architecturally attractive structure. Over the door is a bronze tablet bearing a bas relief portrait of this man, figure 6, designed by Mr. Henry H. Kitson, Lee, Mass., with the following inscription:

> This building is erected to commemorate the acquisition of the Pequannock Water Supply by the City of Newark.
>
> JOSEPH E. HAYNES, MAYOR
> 1884–1893

Through the long mayoralty of Mr. Haynes he took a very active interest in the city's water supply and was prominent in the negotiations leading up to the acquisition of the present supply. It was felt that the opportunity to commemorate permanently in this way his important services to the city many years earlier should not be neglected. The interior as well as the exterior of the building has been planned and constructed with this thought of a memorial structure in mind.

Mr. Arthur R. Denman, formerly chairman of the water department, and Mr. M. R. Sherrerd, chief engineer of the city of Newark, were primarily responsible for the erection of this memorial. The author planned the hydraulic features in connection with the tower and also designed the structure itself.

TEMPORARY CONTAMINATION OF A DEEP WELL SUPPLY AT MONTGOMERY, ALABAMA[1]

By G. H. Hazlehurst[2]

There was a phenomenal rainfall in Alabama from the night of December 7 until the morning of December 10, 1919. A precipitation of 9.6 inches was recorded at Montgomery for this period, with like amounts for Selma, Birmingham, Gadsden, Lanett and other points. The Coosa and Tallapoosa rivers rose with unprecedented rapidity, until a flood stage of 57.1 feet was reached on the Alabama River, the highest water recorded since 1886. The north portion of Montgomery was flooded, the water reaching the roofs of the houses in many places. Not realizing the situation, the operating engineer at the water works left at his usual time on the evening of December 9. He was called to the plant just before the water began entering at 1.30 a.m. of December 10. Trouble was experienced in operating, as the water was kept out of the motors with great difficulty, and it stood from 1 to 2 feet over the north yard where there are four 52-foot circular concrete storage reservoirs, 20 feet deep.

Montgomery is supplied with water from 18 deep wells in the north portion of the city and two in the east portion. The northern wells draw water from depths varying from 200 to 600 feet and are pumped by air. These wells discharge into the four circular concrete reservoirs, with a combined storage capacity of approximately 1,200,000 gallons. From these basins the water is pumped to the mains, at the rate of about 3,000,000 gallons per 24 hours. The two eastern wells draw water from depths of 75 and 135 feet respectively. These have an approximate capacity of 2,000,000 gallons per twenty-four hours, and are pumped by submerged, vertical multi-stage deep well centrifugal pumps, electrically driven, operating normally at 125 pounds pressure and discharging directly into the mains.

[1] Discussion of this paper is requested and should be sent to the Editor.

[2] Sanitary Engineer, State Board of Health, Montgomery, Ala.

The flood water rose above the ground level at every well. The air-lift or northern wells have well heads wherein the air exhausts and the water is collected before leaving for the collecting basins. These wells were assumed to be tight, as no water or air leaks ever showed. The well heads remained in each instance above high water level. The eastern wells were assumed to be tight, as the outside casing terminated in a concrete box, through one vertical side of which the discharge tee on the discharge pipe was run. This box was covered with the base plate of the motor, the joint being well cemented, and the stuffing box for the vertical shaft water-tight.

The county health officer became anxious about the water and went to the plant at noon on December 11. The four basins are numbered consecutively from west to east. Basin 1 was found to contain clear water; the flood water level being above the ground level but 5 feet below the basin rim. The water in Basin No. 2 was low, and slightly turbid. In Basin No. 3 the supply was also low, the water being very turbid. Basin No. 4 contained slightly turbid water. The depth of flood water increased from Basin No. 1 to Basin No. 4, the depth about the latter being 2 feet or more. A slight infiltration below ground was seen in Basins No. 2 and No. 3. These were at once cut out of service and Basins No. 1 and No. 4 used for pumping.

Samples for analysis were taken from the mains and the analyses made in the State Laboratory. B. coli showed in all dilutions, with the total bacteria too numerous to count.

No pumps were operating on December 12 until 5.00 p.m., due to the water power dam having failed and the local stand-by steam plant being temporarily out of service. At this time the flood waters had receded far enough to permit an inspection of the wells at the pumping station. Two of these were found to be delivering a very turbid water. They were at once turned into Basins No. 2 and No. 3, which were not being used, but which had been connected with the outfall, so as to drain as soon as the river was low enough to permit it.

On December 13, the City Commission, in conference with the Health Officer, advised the people, through the press, to boil all water used for strictly domestic purposes. No attempt was made to sterilize the whole supply as no one connected with the Water Department was informed as to the practical methods.

Not until the morning of December 15 could the City Health Officer secure the aid of the State Sanitary Engineer, who had been held at Speigners by a railway washout. When he reached the city, a temporary chlorinating apparatus, consisting of two barrels, a curb cock to control the solution, and a feed pipe into the effluent was installed on December 15 so as to dose all the water from the air lift wells in Basins No. 1 and No. 4 at the pumping station. As Basins 2 and 3 were out of service, this cared for all the water delivered by the air lift wells, including the two cut out on account of turbidity, which had cleared up and been put back into service on account of water shortage. The 700,000-gallon filter plant, normally handling water from the river for the use of the railroads, had been flooded and put out of commission. This caused the railroads to draw on the domestic supply, which was to that extent short.

The chlorine dose was regulated by hand and controlled by the ortho-tolidine test, a residual amount of 0.2 part per million being obtained.

Samples for analysis were taken from each well.

Only one of the eastern wells was in service. The water which it delivered was entering the supply untreated, under a pressure of 120 pounds. It was not possible to chlorinate this supply as no pressure apparatus was available. An examination showed the well was not water-tight. Pine straw had been sucked in large quantities towards the foundation around the discharge pipe. Upon examination it was at once seen that one side of the concrete box forming the motor base and terminating the outside casing, was gone completely, leaving the annular space between the 16-inch outer casing and the 8-inch discharge pipe open for the entrance of the flood waters.

A two-barrel apparatus for chlorine, introduced as a solution of chloride of lime, was installed. The dose was controlled chemically as at Basins No. 1 and No. 4 and the amount was held at the same standard. When the pump was not in operation there could be heard a small stream of water splashing on the annular water surface between the outer casing and the drop pipe. This could not come from the drop pipe, as it immediately empties upon the stopping of the motor, the water running back through the centrifugal pump. This led to the belief that there was a leak in the casing which must be discovered by a mirror or by cutting the oundation, as direct sight was not possible. Any leak in this

casing was doubly dangerous, as an open ditch draining a considerable area flows within 15 feet of the well.

The results of the analyses made on the samples taken December 15 showed that the air-lift wells, which had furnished turbid water, had been grossly polluted, as were both of the eastern wells. A second set of samples was analyzed and the results confirmed those of the first set.

The basins at the pumping station are connected to the river through an overflow and blow-off pipe. The lower pipes are controlled by gate valves, the upper ones by check valves, with no gate valve in the line. The overflow pipe from Basins 1 and 2 enters one side of a tee, with a check valve between Basin 2 and the fitting. Basins 3 and 4 are so connected in series to the other arm of the tee, with the check valve between Basin 3 and the tee. It was thought possible that river water backed through the check valves, the basins, and into the wells during the period the plant was shut down. An examination showed it was impossible for river water to enter the wells this way, for the well heads were above high water. The check valves were examined, however, and one was found to have a piece of 1 by 8-inch plank about 12 inches long wedged so as to prevent the check from seating. There can be no doubt that river water entered Basin 2 through this valve.

The two air-lift wells which furnished turbid water and were found to be polluted, are dug on very low ground, which was twelve feet under water during the flood. An examination showed their construction to be different from that of the other wells. These wells are constructed of three pipes: an outside casing, 8 inches in diameter in one instance and 14 inches in the other; a water-lift pipe inside a 5-inch air pressure pipe, the two being supported on the outside casings by bushings bearing on inverted bell shaped castings resting on the casing tops.

At each well there was a space between the bell and the outside casing. Cinders had floated and stuck in this space which led to the belief that water had been sucked down. A split box, made of 2-inch kiln dried lumber, 2 by 2 by 2 feet, was bolted around the outside casing, so as to submerge any openings. A ½-inch stream of water was turned on and the water went in under the bell and around the opening at the bell so fast that the box would not fill. This demonstrated the fact that water entered the well.

To demonstrate the fact that this water was pumped out of the discharge pipe after passing down 400 feet, 12 ounces of chloride of lime were added every 30 minutes for two hours, and the effluent tested. The ½-inch stream ran for 1¾ hours, when a very strong test for chlorine was obtained on the discharged water. This demonstrated without a doubt, how and where the muddy river water entered these wells.

The four wells which showed such poor results on the laboratory tests were receiving surface water which was entering directly into the wells as described. As soon as the high water receded, the contamination ceased. No stratum has been or is contaminated, as was at first thought. This is shown by the laboratory findings on the other wells, and also a test made on the eastern wells after three days of chlorinating. The chlorine was shut off, the valve on the discharge set to waste the water, and a sample taken after the chemical test showed the water free of chlorine. The water was very low in bacteria, with colon absent.

TYPHOID FEVER OUTBREAK AT TONAWANDA, NEW YORK[1]

By Theodore Horton[2]

On December 30, 1919, the author submitted a report to the State Commissioner of Health of New York, Dr. Hermann M. Biggs, on an epidemic of typhoid fever at Tonawanda which had been long predicted and, when it came, was checked by means which would have prevented it had they been provided when the local authorities were urged to give the matter consideration. The facts in the case, as developed from the official records and examinations made at Tonawanda by Dr. Senftner, epidemiologist of the State Department of Health, and E. S. Chase and Earl Devendorf, assistant engineers, are as follows:

The water supply for the city has been drawn from an intake crib in the Niagara River about 1800 feet from the American shore in about 30 feet of water. The crib or pier is at a point in the river where the water is ordinarily less polluted than it is nearer the American shore. The typhoid rate in the city has always been high, although there is no record of any epidemic reaching the proportions of that in the autumn of 1919. For years this supply had been used without any purification whatever despite the urgent recommendations of the State health officials that some form of treatment was greatly needed. To show how slow local officials sometimes are to heed the warnings of specialists that water supplies are in danger of serious pollution, the record of the notices sent to the Tonawanda officials is given here:

In 1912 a report was submitted recommending the immediate purification of the existing supply or the introduction of a satisfactory new supply. In 1916, a report was made recommending filtration and sterilization, and the immediate installation of duplicate chlorination apparatus. In 1918, the principal assistant engineer of the State Department of Health appeared before the common council and board of health and urged the installation of a chlorination

[1] Discussions of this paper are desired and should be sent to the Editor.

[2] Chief Engineer, State Department of Health, Albany, N. Y.

apparatus; later a letter was sent to the superintendent of the water works giving the names of manufacturers of chlorination apparatus and general advice concerning chlorination. On January 25, 1919, a letter was sent to the mayor explaining the need of chlorination. No acknowledgment was received so on April 4, 1919, another letter was sent to him covering the same points. No acknowledgment was received, so a third letter was sent to him on June 5, 1919, which was acknowledged on June 18 by the city clerk, who stated that nothing had been done about chlorination. Before that answer was received an inquiry was sent to the superintendent of water works asking what steps had been taken to treat the water, and the superintendent replied promptly that nothing had been done. On July 19, 1919, the secretary of the Chamber of Commerce was urged to press the need of immediate chlorination of the water supply upon the city authorities.

As a result of orders issued by the federal government the intake main had to be lowered to permit dredging a deeper ship channel in the river. The work was begun in the spring of 1919 and involved laying a 48-inch wood-stave intake main at the required depth, which entailed crossing and breaking through the old intake line 350 feet or more nearer the American shore than the intake crib. At the point where the old intake was broken the water is more polluted than at the crib. The break was made some time between June 19 and July 4. Following it there were many cases of severe intestinal illness in the city and somewhat later, a few cases of typhoid fever. On July 8 advertisements were printed in the newspapers advising all persons to boil water used for drinking purposes and circulars were distributed from house to house warning everybody of the danger of drinking water which had not been boiled.

On July 19, a letter was received from the secretary of the Chamber of Commerce advising the State Department of Health of the breaking of the old intake line and asking for analyses of the supply. Authorization to collect the samples was given at once, and attention was again called to the importance of the purification of the supply. Nothing was said about the prevalence of typhoid fever in the letter from the Chamber of Commerce, and it was not until August 7 that the State Department was informed of the fact. Its emergency chlorination apparatus was at once shipped to Tonawanda and an engineer was sent to the city. He found that the city officials had ordered a liquid chlorine apparatus which was then on its way by express.

The city's chlorination apparatus was installed and started on August 11, 1919, and has been in use since then. There are two manual control solution feed chlorinators installed in the suction well and the chlorine solution is applied to the raw water in the well before it enters the suctions of the pumps. Every time the installation has been visited by the engineers of the State Department it has been found to be carefully and properly operated.

There were 236 cases of typhoid fever having onsets between July 5 and October 4, 1919. Of these 202 were residents of Tonawanda and the remaining 34 cases were residents of neighboring municipalities and suspected of being infected at Tonawanda. The majority of the cases in Tonawanda occurred between July 4 and September 15, beginning soon after the break in the old intake and continuing for about four weeks after the installation of the chlorination plant, the latter plainly checking the outbreak. Considering the character of the raw water during this period, of which more will be said later, it is noteworthy that chlorination alone was effective. Since October but five cases have been reported. The investigations of the Department's representatives showed that local wells and an industrial water supply occasionally used for drinking water may have had some influence on the typhoid case rate, but the evidence is clear that the city water was the principal source of infection.

The character of the river water as pumped between September 15 and October 3 was so bad that the water works superintendent was confident that something was wrong with the new intake line. On October 3 an examination was made by a diver employed by the contractors and he found a leak near the American shore, where the pipe was 4 inches off center, leaving a large opening for water to enter the intake. This was repaired by placing a sleeve around the joint. A few days later the diver found another leak about 300 feet from the intake crib, where one end of a length of pipe was in such bad condition that it had to be replaced, which work was completed October 14. So far as known to the author, this is the last work done on the line. The trench in which the pipe was laid has been back-filled to a depth of about 4 feet.

During the period from September 15 to October 4, while the intake was leaking, it is reported that water of very objectionable character was delivered to the city. In fact, it is reported that particles of garbage and offal were removed from the pumps and suction well during the latter part of September.

A WATER SUPPLY OF THE SERVICE OF SUPPLIES, A. E. F.[1]

By Jack J. Hinman, Jr.[2]

The American Embarkation Center, of which the chief town was Le Mans, extended over an irregular area which took in the cities of Nogent-le-Rotrou, Alencon, Laval, Chateau Gontier, La Fleche, Vendome, and St. Calais. It thus included all of the Department of the Sarthe and parts of the Departments of Eure-et-Loire, Orne, Mayenne, Maine-et-Loire and Loir-et-Cher. The maximum diameter was about 150 kilometers (93 miles) and the minimum diameter rather more than 100 kilometers (62 miles). Le Mans with its pre-war population of about 70,000, Laval with its 30,000 and Alencon with about 20,000 were easily the most important places in the area.

Le Mans, besides being the most important town in normal times, was the most important town to the Center. It is an important railway point on the Paris to Brest line, and it offers connections for St. Nazaire by way of Angers, for Tours by way of Chateau du Loir, and for Rouen and Le Havre by way of Alencon. In addition to these and other broad-gauge lines, there are a number of narrow-gauge departmental railways, known as *tramways à vapeur*.

It is situated at the junction of the Sarthe and Huisne rivers. The Sarthe is the larger and more important of the two and joins the Loir a short distance above Angers. The Huisne rises between Nogent-le-Rotrou and Chartres, and is followed by the Paris-Brest railroad.

The American camps in and in the outskirts of Le Mans were the Forwarding Camp, known to the French as *Camp d'Arnage*, the Classification Camp, the Belgian Camp, known also as *Camp d'Auvours*, the Spur Camp, Camp d'Etat, Maroc yards, and the

[1] Read before the Iowa Section, October 22, 1919, and published by permission of the Surgeon General, U. S. A. Discussion of this paper is requested and should be sent to the Editor.

[2] State University of Iowa, Iowa City; recently Captain, Sanitary Corps, A. E. F.

camp at the Salvage plant at Pontlieu. There were a number of smaller camps, such as those at the Place des Jacobins, and the engineer camp on the road to Yvre-l'Eveque, as well as Base Hospital No. 52, located in the old Abbey of St. Vincent, near the Cathedral of St. Julien. The capacity of the Forwarding Camp was about 45,000 men, and the capacity of the camps named was well in excess of 100,000 men, taken all together. A large number of the officers and men of the permanent organization were billeted in the homes of the citizens, or housed in small groups, as was the case with the men assigned to the Base Laboratory, who lived in a part of a French garage in the rue Dubignon.

In connection with the Center there were eight divisional areas into which divisions were brought on their arrival in the Center. The areas were known by the name of the towns which were the headquarters of the division. Smaller towns would be brigade and regimental headquarters. One or more companies would be billeted in a village or town, according to its capacity. Each area had its camp hospital or provisions for one, and a permanent staff of area officers, town majors and military police, subsistence depots, and so on. The areas were known as the Montfort, La Ferte Bernard, Ballon, Conlie, La Suze, Sable, Chateau Gontier and Eccomoy areas. There were a number of small camps, especially of labor companies, in the forests north of Alencon, but the only camp of any size outside of the environs of Le Mans was the Holding Camp at La Suze. It will be seen from the above that the Embarkation Center had a capacity of over 300,000 men, but so far as the author knows there were never concentrated there much over 250,000.

From a water supply standpoint, the Embarkation Center was an interesting area. The water sources were most varied, ranging from the modern plants at Le Mans and Laval to springs and country wells of a very unsatisfactory sort.

The United States Engineers constructed a 500,000-gallon Roberts tub filter plant at Pontlieu to supply the Forwarding Camp and the large laundry of the Salvage plant. It used water from the Huisne river. There were wells at the Forwarding Camp (2), at the Belgian Camp (2), and at the Spur Camp (1), each equipped with chlorinators. A large manometer solution feed chlorinator was installed at the Le Mans city filter plant at l'Epau. The city water was the supply of the Spur Camp, Classification Camp, Camp Etat and Maroc yards, as well as of the troops quartered within

the city itself. The troops at La Suze were practically dependent on water filtered and chlorinated by a sterilab[3] under the charge of a first-class sergeant and a private of the Water Analysis Section.

In the small towns the local supplies and wells were used. Continual effort was made to see that the water supplied to each individual detachment was properly chlorinated before use, for, as the "Guide-Joanne" says of the region: "The water is often mediocre and one will do well to investigate its origin, to filter it with care, or to drink mineral water, if the source appears doubtful." Strange as it may seem, the two wells at the Belgian Camp, an old camp occupied at one time by Belgian troops and at another by German prisoners, were very good. Although continually being pumped dry, they showed a bacterial count below 10 per cubic centimeter on agar at 37°C., and no gas-formers in 50 cc. consistently. They were examined daily.

The amount of chlorine necessary for some of the well and stream waters was relatively very great. Usually one to two parts per million were required for a filtered water, except in the case of the Le Mans city plant. At the Le Mans plant 0.30 part per million was ample. When treating an unfiltered stream water as much as 3.5 parts per million was used at times. The above refers throughout to liquid chlorine, as the bleaching powder or hypochlorite of lime was entirely restricted to Lyster bag chlorination.

Two, three and sometimes four officers of the laboratory were kept in the field checking up the treatment of Lyster bags[4] in the various divisional areas. An attempt was made to give the officers of new units the necessary information about supplies, and to instruct the mess sergeants or other non-commissioned officers in charge of the chlorination in the proper method of treating water in Lyster bags, using the tubes of calcium hypochlorite supplied with the rations by the Quartermaster Department. All of these tubes were not of the required strength, as in addition to the errors incident to their manufacture, a variable percentage showed very fine cracks. These cracks were sufficient to allow the escape of chlorine and the entrance of moisture. When the powder in a tube was dry it was rather good evidence that the tube was in good shape, but if the powder was damp, the tube was imperfect. The discarding of such tubes was advised. In treating the water, it was desired to

[3] JOURNAL, September, 1919, page 562; November, 1919, page 635.
[4] JOURNAL, November, 1919, page 627.

leave a slight excess of chlorine, but to keep the quantity as low as consistent with good results. The reason for this was, of course, to minimize the objectionable chlorine taste.

The wells constructed by United States troops at the camps mentioned earlier were from 20 to 30 feet deep. With the exception of Well 1 at the Forwarding Camp, they were pumped by gasoline-engine-driven centrifugal pumps. The chlorinators were of the bubble meter solution feed type and gave excellent results.

The United States filter plant at Pontlieu consisted of two cylindrical wooden sedimentation tanks, 13 feet, 6 inches in diameter by 11 feet, 6 inches deep; an elevated 12,000-gallon wooden wash-water tank with drain 24 feet above ground level; a wooden filter tank, 15 feet in diameter and 7 feet deep, with circular feed trough and mechanical agitation; two wooden alum tanks, 7 feet in diameter and 6 feet deep, with the usual orifice tanks; and a rectangular concrete uncovered clear-well holding 21,000 gallons at normal level. On the effluent pipe from this clear-well was a connection to a chlorinator of the syphon-meter, solution feed type, while a second and similar machine was installed in the pump house for use in case it should become necessary to pump raw water from the River Huisne. The pumps consisted of two high-service and two low-service single-stage centrifugal pumps driven by gasoline engines. There was installed in an adjacent shed a stand-by pumping equipment of an English portable steam boiler and a duplex pump. The water was pumped through about 3000 feet of 10-inch screwed-joint pipe to the tanks at the Forwarding Camp from which it was distributed in the usual way.

The river water was somewhat highly colored and contained considerable organic matter which consumed chlorine. During the time the plant was in operation the turbidity was not very high. About 70 pounds of aluminum sulphate were used to the million gallons. The product was clear and somewhat decolorized, but required a considerable dose of chlorine to make it entirely satisfactory, on account of the chlorine-consuming substances present.

The Le Mans city water plant is interesting because it is a well-conducted modern French installation. It was commenced in 1904 after a commission had made visits to Paris, London, Antwerp, Rotterdam, Hamburg and other important places. Operation of the plant began in August, 1906. An earlier plant at the Gué (or ford) de Maulny supplied raw water from the Huisne. The present

plant is located at the Barrage de l'Epau on the Huisne about 3 kilometers (1.9 miles) from Le Mans. The plant is well constructed with attractive buildings.

In design the filter plant is a Puech-Chabal plant. The raw water is run over a series of aerating cascades and then put through a set of four roughing filters or *dégrossisseurs*. From these it proceeds to a set of ten similar units of slow sand filters, thence to a small reservoir, to which chlorine was added. The water is then elevated to a reservoir 65 meters (211.4 feet) above the plant on the hill called Gazonfier.

The total area of the roughing filters is 2500 square meters (0.51 acre). There are two sets of four elements each, 26.60 meters long (87.25 feet) and varying in depth from the coarsest to the finest from 2.25 to 2.62 meters (7 feet, 4 inches to 8 feet, 7 inches).

TABLE 1

Roughing filters of the Le Mans water works

ELEMENT	WIDTH	GRAVEL DEPTH	SIZE OF GRAVEL
1st	2.30 m. (7.54 ft.)	0.25 m. (9.85 in.)	10 to 15 mm. (0.39 to 0.59 in.)
2d	2.80 m. (9.18 ft.)	0.30 m. (11.82 in.)	7 to 10 mm. (0.28 to 0.39 in.)
3d	4.45 m. (14.60 ft.)	0.30 m. (11.82 in.)	4 to 7 mm. (0.16 to 0.28 in.)
4th	6.95 m. (24.27 ft.)	0.35 m. (13.79 in.)	3 to 4 mm. (0.12 to 0.16 in.)

The roughing filters are arranged in steps so that the water flows from one to the next under the influence of a head of a few inches. Each roughing filter is wider and uses a smaller size of gravel than the one before it (see table 1). The increase in area is intended to keep the output relatively uniform for all elements. The gravel is supported on perforated metal sheets.

When a roughing filter unit is to be cleaned, a trench is dug across one end, after draining the bed. With a powerful stream of water the gravel is shifted, so that the trench is moved across the entire length of the unit. The wash water is, of course, run to the sewer.

The distinctive feature of the Puech-Chabal plant is these roughing filters or *dégrossisseurs*. They are claimed to remove quite uniformly 50 per cent of the turbidity and 70 to 90 per cent of the bacteria from the raw water.

The effluent from the roughing filters passes to a series of uncovered slow-sand filter units. There are ten of these units each of inside measurements as follows: 27.20 by 36.40 by 2.10 meters (89.2 by 116.1 by 6.9 feet). They are set about 0.60 meter (2 feet) lower than the roughing filters. The bottom is made up of semicylindrical inverted collectors and porous blocks, supported on brick. The porous blocks are made of coarse gravel to which has been added just enough cement to hold them together firmly. The sand bed is 0.80 to 0.90 meter thick (31½ to 35½ inches). The depth of water on the sand is 1 meter (39.4 inches). The maximum rate of filtration is 2.40 cubic meters per day per square meter of filter surface (equivalent to 2,180,000 gallons per acre per day or 50.1 gallons per square foot per day). The sand used is a washed and graded river sand, of which the grains are 2 mm. and less in diameter. The output of the filters is regulated by syphon rate controllers of the Didelon type.

Cleaning the filters is done by hand in the ordinary way. Long-handled shovels and wheelbarrows are used, but the shifting of the sand outside of the filter itself is done chiefly by means of hand-operated, V-shaped dump cars. Hydraulic ejectors are not in use. In cleaning, about 2 to 3 centimeters (¾ to 1 inch) of soiled sand is removed, keeping the surface as nearly level as possible. The cleaned filter is then filled from below with filtered water and put into service.

The filters require four to ten days to ripen, according to the season and temperature. While ripening the filter is not allowed to perform its duties in the regular manner. The effluent is diverted and re-pumped to the surface of a mature filter until such time as bacteriological tests of the effluent from the newly cleaned filter show that it is performing its work satisfactorily. Once in shape to do full service, the run of the filter will be from three weeks in winter when the continual rains bring turbid waters, to three months during the summer. Finally it becomes necessary to clean the filter again. After about ten cleanings, the sand layer is reduced to about 0.25 to 0.30 meter (10 to 12 inches) and clean sand to bring the depth up to 0.80 to 0.90 meter (31.5 to 34.5 inches) must be added.

The sand washer was built in Le Mans by MM. Deschamps and Houlbert. It has two units of 3 to 3.5 cubic meters capacity per hour. It is run by an electric motor. It washes and grades the

sand and delivers it to the dump cars. The elevation of the sand to the top of the machine is accomplished by means of a small bucket conveyor for each unit.

The filter effluent passes directly to a 600-cubic meter (158,500-gallon) rectangular concrete covered clear well. It was into the inlet of this reservoir that the chlorine solution was discharged. As stated before, the chlorinator was a solution-feed machine with manometer meter and manual control.

The main reservoir on the hill Gazonfier has a capacity of 14,500 cubic meters (3,830,000 gallons). It is trapezoidal in shape, rather than rectangular, and is divided into two basins which may be operated independently or together, as they communicate by 450-millimeter gates (18 inches). The reservoir is covered, with the roof carried on pillars of reinforced concrete 0.25 meter (10 inches) in diameter, spaced 4 meters apart (13.12 feet) on centers. The walls are of masonry covered by cement. They are 5 meters (16.4 feet) high, but the water level is carried at 4 meters (13.12 feet). Two 450-millimeter (18 inches) feed lines deliver to a single chamber into which the entering water falls down a series of steps or cascades. From the entrance chamber the water flows through two 600-millimeter gates (24-inch) to the main compartments. Each chamber has a 600-millimeter (24-inch) outlet pipe. These pipes are joined, but run separately to the city.

The pumping plant includes steam, electric and hydraulic machinery. The electrically driven centrifugal pumps may derive their power from either the hydraulic plant or the steam plant through a dynamo arranged to be driven in either manner. These centrifugal pumps are used to raise the raw river water to the filter plant, while the hydraulically driven pumps and the steam pumps are employed in elevating the filtered water to the service reservoir on the hill Gazonfier. Filtered water from a newly cleaned unit in which the filter is ripening is returned to the surface of a matured filter by one of two of the centrifugal pumps.

The hydraulic plant has two undershot wheels, each with 64 curved blades 2 meters (6.56 feet) wide, according to the system Sagebien. The wheels are 8.5 meters (27.9 feet) in diameter and 5 meters wide (16.4 feet) and weigh about 50 metric tons (55.1 tons) each. The fall in the river at the dam is practically constant at 1.56 meters (5.12 feet); the speed of the wheels is controlled by gates. From 52 to 176 metric horse power is produced. At the

normal speed the wheels make 1.8 turns per minute corresponding to eight turns of the intermediate gearing and 32 complete strokes of the pumps.

There are two pumping units consisting of two pumps each. Each pump is capable of lifting 35 to 60 liters (9.24 to 15.85 gallons) per second, depending on the speed of the water wheels. The usual rate of pumpage for the hydraulic plant as a whole is 113.6 liters (300 gallons) per second, equivalent to 9821 cubic meters (2,595,000 gallons) per day of twenty-four hours.

There is also a shaft run by the No. 2 wheel which transmits power to the dynamo actuating the electric pumps. The normal speed of this shaft is 120 revolutions per minute.

The electrically operated pumps consist of four Farcot single-stage centrifugal units, each with its motor. They are located in the steam engine house, about 20 meters (65.6 feet) to the north of the hydraulic station. The two stations are separated by a canal and a pump well for filtered water which holds 350 cubic meters (92,500 gallons). The electric generator furnishing current for the pumps and the motors is a Thomson-Houston direct current machine. At 675 revolutions per minute the centrifugal pumps can each lift 66.2 liters (23.3 gallons) per second. The power required to operate the pumps varies from 8.60 to 11.1 metric horse power according as the lift from the river varies from 5.34 to 6.90 meters (17.51 to 22.6 feet).

The steam pumping engines consist of three Weyher & Richmond units. The pumps are of a type known as Meunier horizontal. The engines are run from 30 to 45 revolutions per minute according to the pumping requirements, but the normal speed is 36 revolutions per minute. The capacity of the smaller engines is 120 liters per stroke (31.7 gallons) and of the large engine 204 liters (53.9 gallons). The smaller engines can each pump from 5200 to 7800 cubic meters (1,374,000 to 2,060,000 gallons per day) while the large engine pumps from 8800 to 13,200 cubic meters (2,324,000 to 3,479,000 gallons).

The steam boilers are in two groups of three units each. Like the rest of the pumping machinery they were installed by Weyher & Richmond, of Pantin, Seine. They are horizontal fire-tube boilers, and usually operate at 6.5 kilograms per square centimeter equivalent to 92.4 pounds per square inch. The safety valve is set at 7 kilograms per square centimeter (99.6 pounds per square inch).

About 8.5 kilograms of steam per kilogram of coal of good quality is the performance claimed. There are the usual boiler feed pumps and other accessories. The boilers are hand-stoked. The brick chimney is 30 meters (98.4 feet) high.

The maximum rate of consumption for the city was calculated at 20,000 cubic meters per day (5,280,000 gallons). This seems a rather low value to Americans for a city of 70,000 people, when considering figuring maximum rate, or perhaps it would be better to say that we are accustomed to think in terms made large by the wasteful habits of the consumers. At any event, the Le Mans plant is equipped to handle water at that rate and at the same time have one centrifugal pump, one steam pump and one boiler out of service.

The plant actually produces from 8000 to 15,000 cubic meters (2,113,600 to 3,963,500 gallons) per day, with an average of 10,000 cubic meters (2,642,000 gallons).

During the time the author was in charge of the water analysis work of the American Embarkation Center at Le Mans, the laboratory checked the condition of the city water every day. The French military laboratory in the city did the same thing, and the municipal laboratory carried out more systematic investigations. All laboratories used their own media and the methods did not correspond throughout. The water was quite satisfactory according to the findings of all the laboratories, but the small amount of chlorine added by the American chlorinator was an advantage. Only about 2 pounds per million gallons were employed.

The author considers that the city of Le Mans is very fortunate in having its water purification plant operated under the direction of such capable and well-informed men as Louis Thureau, chief of operations at l'Epau plant, and A. L. Marchadier, director of the municipal laboratories.

NOTES ON EXPERIENCES WITH THE PRESUMPTIVE AND CONFIRMATORY TESTS FOR B. COLI IN WATER ANALYSIS FOR THE AMERICAN EXPEDITIONARY FORCES[1]

By Max Levine[2]

In the routine bacteriological analysis of water, disease producing microörganisms are not sought for nor are they likely to be detected, even in a dangerous water. It devolves upon the analyst to interpret his bacteriologic findings, and in this he is aided materially by the determination of the incidence of B. coli. Tests for this organism were carried out in the following manner:

Five 10 cc., two 1 cc. and one 0.1 cc. portions of the water under consideration were placed in lactose broth and incubated at 37°C. After twenty-four hours, the amount of gas in each tube was recorded and those showing no gas were replaced in the incubator for another twenty-four hours. Gas formation in one or two days was regarded as presumptive evidence that B. coli may be present, but to confirm this presumption, such tubes were streaked on eosine-methylene-blue agar to be described below.

THE PRESUMPTIVE TEST FOR B. COLI

In dealing with untreated waters, the production of 10 per cent or more gas after twenty-four hours is recognized as a very reliable index of the probable presence of B. coli or its close allies. This is a positive presumptive test. A slower rate of gas production (i.e., where there is less than 10 per cent gas in twenty-four hours, or more than this quantity in forty-eight hours where twenty-four hours was negative) is regarded as an inconclusive or doubtful presumptive test and further confirmation must be carried out.

[1] Read before the Iowa Section, October 22, 1919. Authorized for publication by the Surgeon-General, U. S. Army. Discussions of this paper are requested and should be sent to the Editor.

[2] Bacteriologist, Engineering Experiment Station, Ames, Iowa; recently Captain, Sanitary Corps, A. E. F.

These limitations of the reliability and applicability of the presumptive test were not properly appreciated by many likely to be called upon to examine and report on water specimens. It was the rather prevalent opinion that a small amount of gas in twenty-four hours was of little significance, whereas the production of 10 per cent or more gas in forty-eight hours was regarded as a good index of the probable presence of B. coli. As the presumptive test is often the only one available under campaign or field conditions, and indeed, is too frequently relied upon in the control of water purification plants, it was felt that the observations on this reaction at the

TABLE 1

Showing correlation of rate of gas production with confirmation of the presumptive test for B. coli in lactose broth

RATE OF GAS PRODUCTION	UNTREATED SUPPLIES		CHLORINATED SUPPLIES	
	Number of tubes showing gas	Percentage of gas tubes confirmed	Number of tubes showing gas	Percentage of gas tubes confirmed
Rapid (10 per cent or more in twenty-four hours)	684	97.7	57	44.0
Moderate (less than 10 per cent in twenty-four hours)	193	91.2	15	20.0
Slow (no gas in 24 hours; 10 per cent or more in forty-eight hours)	276	73.2	156	6.4
Very slow (no gas in twenty-four hours; less than 10 per cent in forty-eight hours.)	33	45.5	26	0.0

Central Medical Department Laboratory of the American Expeditionary Forces, based upon the examination of 1559 specimens and comprising waters from both treated and raw supplies from various sources, would be of interest, and perhaps of value for record.

From table 1, it is evident that

1. *The positive presumptive test* (10 per cent or more gas in twenty-four hours) is a very reliable index of the probable presence of B. coli when dealing with untreated waters but it is not to be depended upon when testing chlorinated waters; 97.7 per cent of the former and only 44 per cent of the chlorinated samples showing gas, were confirmed for B. coli or its close allies.

2. *The doubtful presumptive test* (less than 10 per cent gas in twenty-four hours, or more than this quantity in forty-eight hours

where twenty-four hours was negative) is only a fair index of the probable presence of B. coli in untreated waters, while for chlorinated specimens it is practically negligible, as 75.9 per cent of gas tubes from untreated, and only 7.6 per cent of those from chlorinated samples were successfully confirmed.

3. A small amount of gas in twenty-four hours is a more reliable index for B. coli than 10 per cent or more gas in forty-eight hours. The rate of gas production seems more significant than the total volume of gas formed as a presumptive test.

THE PARTIALLY CONFIRMED TEST

For confirming the presumptive test, the simplified eosine-methylene-blue agar was employed in place of the Endo medium because of its ease of preparation and greater stability. This medium also enables us to differentiate between the B. coli and B. aerogenes in a large proportion of instances simultaneously with confirming the presumptive test, as indicated in table 2.

TABLE 2

Reliability of presumptive differentiation of B. coli and B. aerogenes on Eosine-Methylene Blue agar

DESIGNATION FROM APPEARANCE ON AGAR	1918-1919, FRANCE		1917, IOWA	
	Number of colonies tested	Percentage correct	Number of colonies tested	Percentage correct
B. coli	87	94.2	122	96.9
B. aerogenes	55	85.5	102	82.4

Preparation of simplified eosine-methylene-blue agar. This is made up of distilled water, 1000 cc.; peptone (Difco), 10 grams; dipotassium phosphate (K_2HPO_4), 2 grams; agar, 15 grams.

Boil ingredients until dissolved, and make up any loss due to evaporation with distilled water.

Place measured quantities in flasks or bottles and sterilize in the autoclave at 15 pounds pressure for fifteen to twenty minutes.

Just prior to use add to each 100 cc. of the melted agar prepared as above the following: Lactose, 1 gram or 5 cc. of 20 per cent solution; eosine (2 per cent yellow aqueous solution), 2 cc.; methylene blue (0.5 per cent aqueous solution), 2 cc.

Pour medium into petri dishes, allow them to harden, and inoculate by streaking on the surface.

There is no adjustment of the reaction, and filtration of the medium is not necessary.

PRESUMPTIVE DIFFERENTIATION OF B. COLI AND B. AEROGENES ON EOSINE-METHYLENE-BLUE AGAR

B. coli forms flat, dark-centered, button-like colonies 2 to 4 mm. in diameter, which by reflecting light show a characteristic greenish metallic sheen. The colonies of B. aerogenes are generally much larger, convex, with brownish centers, and rarely exhibit a metallic lustre.

To determine the reliability of the presumptive differentiation of B. coli and B. aerogenes on the eosine-methylene-blue agar, 153 colonies were fished from routine confirmatory plates, designated as B. coli or B. aerogenes and later identified more completely. Of 87 supposedly B. coli 94.2 per cent were confirmed, while of 55 designated as B. aerogenes 85.5 per cent were such. Of 11 strains recorded as questionable but probably B. aerogenes, 72.7 were correctly recorded. As this differentiation is obtained simultaneously with the confirmatory test, requiring no additional labor, the use of the eosine-methylene-blue agar should prove of considerable value for routine water analysis.

The presumptive and confirmatory tests are designed to detect all members of the colon group of bacteria. In examining waters we are interested particularly in determining whether wastes from human sources are present, and B. coli is employed as the index. It should be borne in mind, however, that the habitat of coli-like bacteria is not restricted to the human intestine. Similar organisms are characteristic of the animal intestine, and not infrequently are found in the soil and upon grains.

The desirability of differentiating coli-like bacteria from different sources has long been recognized, for it is evident that human pollution is much more dangerous to the public health than animal wastes, and that the latter, in turn, are considerably more objectionable than contamination with soil washings. It is at present impossible to distinguish B. coli from human and other animal sources, but much evidence has been accumulated which indicates that the predominating animal forms are quite distinct from the prevailing types obtained from the soil and upon grains.

Recent studies have demonstrated conclusively that whereas B. coli is a constant inhabitant of the intestinal tract of man and other animals, it is comparatively infrequently encountered in soils, and very rarely found upon grains. B. aerogenes and B. cloacae, on the

other hand, are rare in feces, predominate in the soil, and are practically the only coli-like forms obtained from grains.

The comparative viability of B. coli and B. aerogenes in water, and their relative resistance to chemical or other treatment should be considered in interpreting water analysis. B. aerogenes is said to be more viable and more resistant to treatment; it is even said to multiply in natural waters. In view of these facts, if they are substantiated by further studies and observations, the same sanitary significance should not be accorded B. aerogenes as is given to findings of B. coli, particularly when considering stored or chlorinated waters.

The raw water of the Dijon, France, water supply, examined daily for six months, yielded 96 positive results for members of the colon group, with B. aerogenes present in 15.6 per cent of these. The tap samples during the same period (water was treated with 0.07 to 0.1 part per million chlorine) only showed three positively confirmed specimens while the plant was in operation, but B. aerogenes was present in each instance or 100 per cent of positively confirmed gas tubes. The indication is therefore strong that the B. aerogenes is more resistant to chlorination than is B. coli.

It is not feasible, from our present incomplete knowledge of the types, to put forth any set rules for interpreting the significance of the presence of various members of the colon-aerogenes group in water, but the following is offered as a suggestion.

In ground waters, the presence of B. aerogenes may be given the same weight in the interpretation as is accorded to the presence of B. coli, on the assumption that such waters are essentially filtered supplies and should be free from soil washings. If soil forms of coli-like bacteria are present it may be regarded as an indication of imperfect filtration or improper surface protection, either condition making the supply suspicious.

In stored surface or treated waters, the presence of B. aerogenes alone, on account of its more probable non-fecal origin, greater longevity in water, and apparently greater resistance to treatment, should not be regarded as objectionable as is the presence of the true B. coli in equal numbers.

The proper differentiation of B. coli from B. aerogenes may thus be of practical importance to those who have to deal with treated or surface supplies.

JAVELLIZATION

In the article by Lieut.-Col. F. W. Scheidenhelm in the JOURNAL for November, 1919, on "Keeping the First Army Supplied with Water," there is a reference to the javellization of water, which has brought a number of inquiries for further information about this treatment. Through the courtesy of the Surgeon-General of the Army the following information concerning this subject has been reproduced from appendices to a report by Lieut.-Col. Edward Bartow,[1] who was officer in charge of water analysis laboratories in the American Expeditionary Forces. In authorizing the publication of these notes, the Surgeon-General's Office called attention to features in the use of Javelle water which prevent its being considered the equivalent of the use of ampules of hypochlorite for the sterilization of water for army use. For example, it is bulky, which introduces difficulties in transportation, it is unstable and therefore requires careful control in use, and has a number of other practical disadvantages. Under certain exceptional local conditions where the solution could be standardized, as explained in the following notes, it proved useful in rendering questionable water supplies safe for drinking purposes, but the Surgeon General's Office does not endorse its general substitution for treatment by hypochlorite.

In many cases each water cart, truck, tank car or other water container used in supplying the troops in the field was treated by hand with a sufficient dose of Javelle water (a solution of sodium hypochlorite named after the French originator) to accomplish the required sterilization. Operators, trained by the Sanitary Corps officers, were supplied from the water supply companies or attached Sanitary Corps personnel. The treatment required very little equipment, a few measuring glasses, test tubes, starch iodide solution and Javelle water. These materials were generally secured from the French Service de Santé, and the glassware was calibrated and

[1] Colonel Bartow states that the report on the use of Javelle water was written by Capt. A. S. Behrman, who was in charge of field work during the St. Mihiel and Argonne operations, and that the work in Base 7 was under Capt. Weston Gavett, both of the Sanitary Corps.

the solutions prepared or standardized in the mobile laboratories. The extrait de Javelle obtained from the French contained from 40 to 65 grams of available chlorine per liter. A stock solution of 50 grams per liter was used in javellization, and the fresh supplies of varying strengths were adjusted to this standard.

For javellization of comparatively small quantities of water a weaker solution was prepared on the ground as needed, 1 cc. of which would give a dosage of 1 part per million of chlorine to 1 gallon of water. The glassware used in hand javellization was ordinarily calibrated directly in the number of cubic centimeters corresponding to the number of gallons in the common water containers, such as water carts, Lyster bags, etc. This provided a dosage of 1 part per million of chlorine, which was adjusted when necessary. For hand javellization of large quantities of water, such as railroad tank cars, the strong stock Javelle solution was employed. The hand dosage could be put into operation in less time than a liquid chlorine apparatus, and an operator with hand javellization apparatus could accompany advance parties under circumstances impossible for a mobile purification truck. For clear water, the usual dosage was 1 part per million of chlorine.

The criterion for satisfactory chlorination was that the treated water should show free chlorine for at least thirty minutes after treatment. Results were checked where practicable by bacteriological examinations. Continued experience, however, showed that with clear waters the criterion above indicated was safe. In the case of turbid waters, the dosage had to be increased.

In the St. Mihiel operations, narrow-gauge railway tank cars were filled with water at convenient points and treated with Javelle solution, after which the water was carried forward to small reservoirs in the advance, which served as filling points for water carts, etc. Immediately after the advance a scarcity of water in the vicinity of the Grande Tranchée was relieved by trucks, loaded with tanks and casks of water treated with Javelle solution, which plied on regular routes over the former no-man's-land, supplying the organizations along the route.

In the Argonne-Meuse operations water was treated with Javelle solution by hand dosing at 42 stations.

One of the most interesting instances of the use of Javelle water is given in a special report on work done in Base Section 7, where a number of camps were under construction. The works for each

camp consisted of a well, pump driven by gasoline engine, elevated tank and distribution piping. Poor results had been obtained with Lyster bag treatment, so it was decided that wherever a water system was installed all the water pumped should be sterilized, and as the supplies were small Javelle water was considered worth trying before installing a chlorine apparatus. The results were satisfactory.

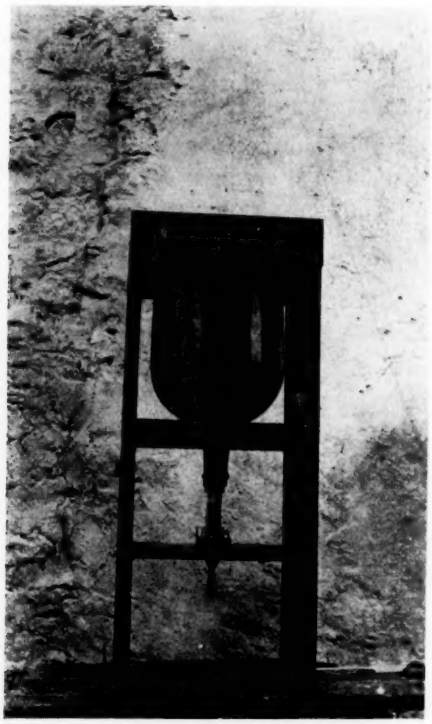
The Javelle water was made in a nearby village by a simple method using crude appliances. A chlorine solution was mixed with a sodium hydroxide solution, the strength adjusted with the aid of a hydrometer, and the solution clarified by sedimentation and filtration. The chlorine water was made by dissolving chlorine gas from a tank of liquid chlorine in a tank of water. The extract showed a strength of 25 to 45 grams of chlorine per liter, and was sold in liter bottles for household purposes, to be diluted ten times to make eau de Javelle.

An attempt was first made to regulate the dose of Javelle water by the drop method. It was found that the variation in the rate of application possible with this method was very limited, and that slow rates made it difficult to maintain a constant setting. The operator was required to regulate the flow, which introduced a chance for additional errors. It was then decided to keep the flow constant by using a fixed orifice operating under a constant head, and change the rate of application of the chlorine by altering the quantity of Javelle water added to the carboy from which the solution was fed. This reduced the duties of the operator to filling the carboy when it became empty, which did not happen more often than once in twelve hours, and keeping the orifice clean. With a smooth orifice, a smooth, even stream was obtained and any clogging was apparent.

Experiments showed that the minimum flow that could be used without excessive clogging of the orifice was 2 liters an hour under 5 inches head. For a given installation an orifice was chosen that would empty a carboy in a day or less. A 10-liter carboy was chosen finally as most generally convenient. It was supported on a wooden frame and closed by a stopper with two holes. Two short glass tubes were inserted in these holes and rubber tubes connected to them. The flow through these tubes could be stopped by pinch cocks or hard rubber valves. The tubes discharged into a funnel containing the orifice. To keep the liquid from surging too high in the funnel when air escaped into the carboy, it was found necessary to draw out the end of the air inlet tube to a small hole in order

to retard the inflow of air. The water passing through this apparatus dropped into a funnel, as shown below, from which a rubber tube conducted it into the suction pipe of the pump or into the water as close as possible to the foot of the suction pipe.

While developing this continuous-feed machine, the Javelle water was also used experimentally in treating water in Lyster bags. At



Apparatus for Feeding Javelle Water, Base Section 7

first a bottle of the strong Javelle extract, a bottle of test solution, a pipette and instruction sheet were furnished. They were found more easy to use than the hypochlorite of calcium tubes and the results were better. The required amount of water was added by the pipette, and after the treated water had stood for half an hour it was tested with the starch iodide solution. With the same water and bottle of extract the amount of chlorine added was practically the same for each treatment.

At one time a number of small detachments were distributed over the Base on road work, and each was supplied with a kit for javellization. This consisted of an 8-ounce bottle of Javelle extract, a bottle of starch iodide solution, a 5-cc. pipette graduated in cubic centimeters, an ungraduated pipette for the starch solution, and six cloth signs lettered "Good Water" and "Bad Water." This kit was carried in a cigar box with instructions for its use pasted on the inside of the cover. The medical officer or man in charge of water treatment for each detachment was given this kit and good results were obtained from its use. As the average dose per Lyster bag was 3 cc., the bottle of extract was sufficient for about eighty treatments.

An instance showing the convenience of the use of the extract occurred when a French pumping station at Champ de Mars was closed down. All organizations were advised to obtain water at a somewhat more distant station, but several wagons made a practice of obtaining water from a French ice plant near Champ de Mars. The water was fresh but unsafe bacterially. Therefore a man was stationed at this supply with a bottle of Javelle extract, an empty bottle and two pipettes, one for large tanks and one for small tanks. Each pipette had but one graduation mark. All the man had to do was to add the required amount of extract to the empty bottle by means of the proper pipette, fill it with water and add the solution to the tank while it was being filled. Bacterial tests of the water treated in this way showed that it was sterile.

THE RURAL WATER SUPPLY AN INTEGRAL PART OF THE MUNICIPAL SUPPLY[1]

By Dr. E. G. Birge[2]

That Farmer Jones' well, located 5 miles northwest of Rock Rapids, may at any time become an integral part of the municipal supply of Keokuk sounds, on the face of it, a foolish statement, yet the author hopes in the course of these few remarks to prove that such may be the case, and that the water works official should be as vitally interested in that well as in his own municipal supply. Not only is it to his interest to see and to know that Farmer Jones has a pure water supply, but it is to his interest to see that it is kept pure.

To follow out our original premise more fully, let us suppose that one of the citizens of Keokuk drifts up into the northwestern part of the state and lives for a while on the farm in question, returning to Keokuk in apparent good health. Let us furthermore suppose that there has been a typhoid epidemic, a small one, to be sure, merely one of those local flareups that don't get into the paper, that has been traced to the use of a contaminated well existing on our farm. In due time the citizen in question develops a case of typhoid fever. Potentially he is dangerous to the rest of the community, and it is up to the water works superintendent to see that no more cases of typhoid fever develop in Keokuk through the medium of the water. To all intents and purposes that well, situated miles away, has become an integral part of the Keokuk supply and the water in Keokuk must be treated as though it was contaminated.

While that is a concrete case, merely a supposition in this instance, yet the underlying idea is the one which governs the treatment of water in the country at the present time. Were it not for the fact that water supplies, city as well as rural, are in constant danger of being contaminated by the excreta of human beings, the necessity of chemical treatment, of sand filtration and the constant expense

[1] Read before the Iowa Section, October 23, 1919. Discussions are requested and should be sent to the Editor.

[2] State Epidemiologist, State University of Iowa, Iowa City.

of so safe-guarding the watershed as to reduce the danger to a minimum would be largely reduced. Do not get the idea that it would be absolutely done away with in any community. If it could, it would simply mean that the human beings residing in that community would be perfect, a thing unheard of, yet all will agree that if all water supplies could be kept from being contaminated the problems of the water works manager would be solved to a large extent.

Another reason why the water supply must be more carefully watched when there is a case of typhoid in the town, is the fact that the public throws suspicion first on the water supply and should an epidemic arise from that first case, the public always jumps to the conclusion that the water is at fault and it may lead to serious difficulties for the water company. In some instances, even when the water company was not at fault and the water was not contaminated, although the analysis of the water showed the possibility of its being so contaminated, the cities have revoked the franchise of the water company. It is for this reason as much as any other that the water company should be interested in the rural supply, not only of the surrounding country, but of the entire state.

Can that condition be brought about? The first answer to that question is usually, "no." Possibly that is the correct answer; personally the author is optimistic enough to think otherwise. Certainly it cannot be brought about in a short time, nor without a great deal of effort on the part of those most vitally interested, nor can it to a large extent ever be brought to a point of perfection, but that the conditions can to a large extent be improved, and should be improved, goes without saying. What forces are there at our command to tackle this problem and to keep the matter agitated to a point where the public will think about it and see that it is done, for without the public back of the movement it is doomed to failure at the start?

The State Board of Health is the first force we have to deal with, and no board of health worthy the name neglects this important thing for a minute, yet it is a deplorable fact that in most parts of the country the improvement goes on with surprising slowness due no doubt to the multiple activities of the State Board of Health and to the fact that the public looks to them to decrease disease, and this matter of improving water supplies, either municipal or rural, is merely a co-incident step in the reduction of disease. As such it receives its greatest attention at times of epidemics, and usually

only in proportion as the danger lies to the community immediately interested. Usually, too, there is little follow-up work done, and the rural supply, once put into shape, in a short time relapses into its former condition. This is not always the fault of the State Boards of Health; if it were, it would be an awful indictment against men who are giving the best they have towards the betterment of the communities in which they live. Usually it is largely due to apathy on the part of the public and a lack of definite coöperation on the part of other forces working towards the same end. This lack of coöperation is enormous in our public life; various boards and societies, instead of coöperating, overlap on their work, each jealous and afraid that the other fellow is going to spring something new and get the lead.

Can a society such as the American Water Works Association do anything of value along this line? Most assuredly it can and it does; not only that but its members are those who, from a monetary standpoint, are most vitally interested. The Association has always stood for the best in water works practice and it is largely to its efforts that we have the present laws governing municipal water supplies. There is no question but that it would do more work with the rural supplies if it was definitely realized that they may become at any time an integral part of the municipal supply, even if it is only in an indirect manner.

The thing which we would all like to see, not only as professional men but as citizens, is the betterment of the community. That good water tends towards that betterment is unquestioned. In order to keep that water good the general sanitation of the community must be improved. We are all familiar with the Mills-Reincke phenomenon, in which the death rate due to all causes shows a reduction greater than can be accounted for by the drop in deaths from typhoid fever alone, when reduced by the use of filtered water. If that drop in the death rate holds for cities with proper municipal water supplies, think of the reduction in deaths to a state which could say that the biggest proportion of its rural supplies was above suspicion.

The task is a great one; just what the plans of such a campaign would have to be is a question. The present laws concerning the pollution of water in this, as in many other states, relate to the water supplies of cities and incorporated towns. So far as they go they are adequate, but they do not go far enough. The time has passed when any city can clean up its own yard and say, "sufficient." In

the past these conditions undoubtedly held good, in which the rural district was isolated to a greater or less extent, and the pollution of a rural water supply affected only those persons who used it. However, with the coming of the automobile and the advent of good roads, no part of a state, or of the surrounding states, can in any sense of the word be termed isolated. There is altogether too much travelling back and forth and it is too easy for the persons living in remote districts to come into the town, to say that any district, no matter how remote, is isolated from the city. It is those outlying districts in which the water supply is not so carefully watched that are dangerous to the municipalities. On account of the present laws, the strictly rural supplies, and by that is meant the well that supplies the farmer's family and possibly a neighbor or two, are not brought to the attention of the health authorities, either local or state, until disease appears in the neighborhood and suspicion points toward the supply. For the reasons set forth above, it is as necessary to safeguard the strictly rural water supply as it is to safeguard the water supply of the municipality and state. Another benefit which is bound to come from the constant supervision of the individual country water supply is the fact that the surrounding conditions will necessarily be put into better sanitary condition and will be kept in better sanitary condition. Not only will that benefit the water supply itself, but it will benefit the entire catchment area in which that supply is situated. To put it briefly, it will make the sanitary supervision of the municipal water supply more efficient than is possible at the present time.

Such a plan would probably necessitate the establishment of either a district or county health officer, of necessity a full-time man. It might, and probably would, necessitate the establishment of a laboratory centrally located in the district or county. While that would at first seem to put an undue burden of expense on the community, as a matter of fact such a laboratory, designed for examination of water, milk and chemical material, can be made to be nearly, if not quite, self-supporting through private investigations for physicians, investigations not along strictly public health lines. Coöperation in meeting the expense of public health service has worked in other places and it is unreasonable to suppose that it would not work in this State. That the state, county, and municipality could not coöperate in obtaining full-time men of ability is unthinkable. That they might not, is at present probable; but if the demand was great enough, it would in all probability be done.

It is only through such a demand that any improvement is possible. Undoubtedly when it is realized that when proper sanitary conditions obtain in rural districts many of the health problems in urban communities will be materially lessened, that demand will be made. Certainly improved rural sanitation will materially lessen the problems of the city water works manager, both technically and financially, and it would seem reasonable to suppose that the water works engineer should be vitally interested in seeing some such plan established.

Along this same line it appears that the time is fast approaching for other states in the Union to follow in the steps of the New Jersey State Board of Health in the licensing of the water works operators and operators of sewage disposal plants. It is unnecessary to give at this time the exact wording of that law. New Jersey grants four grades of licenses, upon examination. The highest grade is that of the superintendent. The superintendent must be familiar with the operation and chemical treatment of water as well as with the chemical and bacteriological analysis of water. The other grades are for operatives and depend entirely upon the amount of knowledge which the man shows in his line of work. Such a law assures the highest efficiency in the operation of these plants and to a large extent assures the operation of the plants by a proved expert. That such efficiency is desirable, will no doubt be unquestioned, and that it will work for the general betterment of sanitary conditions, as related to water supplies, is also obvious.

The author has tried in this short paper to bring out the fact that the rural water supply is an integral part of the municipal water supply and that the citizens of the community as well as those officials to whom they look for better health conditions should be as vitally interested in the remote well as they are in a well next door. There has been nothing new brought out in this paper, although the angle from which this matter has been taken up may be new to some. Even to those to whom it is an old story, the author would say that any campaign in any community looking toward better sanitary conditions of any kind must take into account the remote country district, if we can still call it remote. Under the present living conditions, all communities are so closely bound together that a campaign for better health conditions in one corner of the state loses a large share of its effect unless that campaign can be taken up throughout the entire state at the same time.

CONCRETE IN WATER WORKS CONSTRUCTION[1]

By A. C. Irwin[2]

Concrete has been used very extensively in various parts of water supply works such as dams, reservoirs, pipe lines, tanks, standpipes, filters, settling basins, power houses, etc. Obviously, a detailed discussion of all these is beyond the limits of a single paper and it will be necessary to confine the discussion to very general terms in order to take up even a few of these items.

Reservoir linings. For slope wall reservoirs the inclination of the banks is usually from 1½:1 to 2:1. The thickness of the concrete lining for the slope is from 4 to 8 inches and is usually placed in slabs from 10 to 20 feet square, depending on whether or not the slabs are reinforced. The slabs are usually laid with butt joints with their ends resting on a sill and the space between the ends of the slabs filled with some elastic material to form an expansion joint. Expansion joints between slabs have been very successfully made by caulking with oakum and overlaying the joints with strips of burlap well painted with asphalt.

The Green River storage basin at Tacoma, Wash., was built with expansion joints ¼-inch wide at the bottom and ¾-inch wide at the top. The sills had tar paper laid on top of them before taking the slabs. The joints were filled with refined asphaltum specified to be pliable between freezing and a temperature of 200°F. and not sticky at 100°F. This joint has proved very satisfactory.

Concrete pressure pipe. Concrete pressure pipe has been successfully used with pressures up to 80 pounds per square inch and there is no doubt but that the pressure which may be handled by concrete pressure pipe is limited only by economy in design and construction.

There are certain requirements which pressure pipe must fulfill, among which are the following: (a), Ability to resist external and

[1] Read before the Iowa Section, October 23, 1919. Parts of the original paper have been materially condensed for publication. Discussions are requested and should be sent to the Editor.

[2] Engineer, Structural Bureau, Portland Cement Association.

internal pressures; (b) low coefficient of friction; (c) minimum leakage; (d) low maintenance charges; (e) permanency; (f) provision for contraction and expansion; (g), low cost consistent with the above requirements.

Concrete pressure pipe designed to withstand internal pressure will be found to be strong enough to withstand all ordinary external pressures, as from backfill, to which it will be subjected. Reinforcing steel is, of course, placed in the shell of concrete pipe to assist in withstanding the bursting pressure and some designers use sufficient steel to take the entire bursting pressure. For long lines of large pipe the pipe is constructed in place or at a convenient point near the general location of its use. Thus transportation expenses are low and the manufacture of the pipe can be given continuous inspection. Regardless of whether or not the strength of the concrete itself in tension is taken into consideration in design, it nevertheless does exist and contributes no small part of the actual strength of the pipe. Where it is not considered in the design, this strength of the pipe affords an extra factor of safety.

Correct methods of manufacture will produce concrete pipe with a low coefficient of friction and negligible leakage. A friction test was conducted on the Sooke Lake water supply conduit for the city of Victoria, B. C. The pipe line is of 42 inches diameter, 27½ miles long and contains 50 per cent of curves with radii varying from 90 to 150 feet. There are in the line seven siphons having a maximum head of 94 feet. The tests were conducted by Wynne Meredith, San Francisco manager of Sanderson & Porter, consulting engineers, and the coefficient of friction (n of Kutter's formula) was found to be 0.01058 at the inlet end and 0.0117 at the outlet of the 27½ miles with the pipe running full at the inlet and six-sevenths full at the outlet. With 20 inches of water at the inlet the water level at the outlet was 19½ inches. Some years ago Marx, Wing and Haskins determined from gaugings on a 6-foot steel riveted pipe values of n from 0.013 to 0.018.

The reinforced concrete pressure pipe line constructed as a part of the Gunpowder water supply for the city of Baltimore, Md., consists of 5000 feet of 108-inch diameter pipe and 3000 feet of 84-inch diameter pipe. This line carries 120,000,000 gallons daily and when tested under a head of 85 feet, the leakage in 24 hours on the entire line amounted to 13,000 gallons, or less than two-hundredth of 1 per cent.

Low maintenance on pipe lines must certainly result if the pipe is of such a material that leaks will not develop from corrosion, electrolysis, etc. Concrete, of course, is not subject to corrosion and since concrete pipe must be made sufficiently dense to prevent leakage it follows that the steel reinforcing in the shell of the pipe is perfectly protected so that corrosion of the steel cannot be expected. Of course concrete pipe lines, as well as those of other material, are subject to such accidents as earth slides and cannot be expected to withstand extraordinary conditions under which no type of pipe line would remain intact. The maintenance, however, on a well constructed reinforced concrete pipe line may, with confidence, be expected to be very low.

Permanence is merely a corollary to low maintenance charges. Rust, rot and decay are not defects of concrete pressure pipe and under ordinary conditions, with only the pressures for which the pipe was originally designed and constructed, concrete pressure pipe may be considered as permanent.

Contraction and expansion will occur in pipe of any material and suitable expansion joints must be provided in concrete pressure conduits if the leakage at joints is to be kept at a minimum. Such joints have been developed for use in precast reinforced concrete pipe and have been successful in practice. As the construction of pipe lines is usually done at temperatures higher than that of the water which will flow through the conduit it necessarily follows that contraction will occur. This will produce cracks at the joints through which leakage of considerable amount will occur if provision has not been made to care for the contraction.

An expansion joint that has been found to take care of expansion and contraction consists of a crimped copper band continuous throughout the circumference of the joint. As the pipe contracts the crimp opens and as the pipe expands the crimp closes. This joint is used in pipes of 36 inches to 108 inches in diameter.

It is well to reduce the number of joints by making the units as long as practicable, and each unit should be equipped with an expansion joint. Trench conditions, such as bracing and handling, will usually determine the practicable length to be about 8 feet.

Pipe are cast on end and the molds of sheet steel and cast iron must be erected on a substantial base or foundation of reinforced concrete, the surface of the foundations being truly level and finished so that when the cast iron base mold is set and the sheet steel casings are erected the casings will be truly vertical.

In the manufacture of most precast concrete pressure pipe, it is necessary to use 1 volume of Portland cement, 1½ volumes of sand and 2½ volumes of coarse aggregate, and this means that 2½ barrels or 950 pounds of cement are used per cubic yard of concrete. In the manufacture of precast pipe for the Winnipeg Aqueduct it was found necessary to use but one sack of cement to 3.8 cubic feet of mixed aggregate, or approximately 2 barrels or 700 pounds of cement per cubic yard of concrete. (The Canadian barrel weighs 350 pounds gross or 346 pounds net.) This minimum quantity of cement was found practicable owing to the very excellent grading of the mixed aggregate which was supplied by the Greater Winnipeg Water District from its own pit at which was located a screening and remixing plant. The concrete is mixed to a quaking or jellylike consistency, which will easily flow to place when slightly puddled.

The mortar for spigots is made of 1 part cement to 2 parts sand and is mixed to the same consistency as the concrete so as to obtain the same rate of setting as nearly as possible. As the spigot mortar settles, more mortar is added until the settlement ceases, when the joint is finished.

Concrete pressure pipe may be successfully manufactured in cold weather with the proper appliances for supplying heat and moisture. In fact, where high speed of manufacture is desired, steam curing should be resorted to and this may be carried on regardless of temperature conditions. For the manufacture of large sizes, appropriate handling equipment and appliances should be provided, such as traveling derricks, locomotive cranes and light industrial tracks, cars and locomotives.

Good pipe under a test pressure of 50 pounds per square inch should show a leakage of only about 400 gallons per mile per 24 hours. This result can be secured by the use of well designed equipment, well graded aggregate, proper methods of manufacture and unremitting care.

The pipe line in Seattle was a trunk water conduit to operate under a head of 90 feet and every pipe was tested to 1½ times the working head. Tests were made on short sections of completed line and the leakage was nil.

In addition to the copper expansion joint type of concrete pressure pipe, there has recently been developed a new type of expansion joint which is very efficient. This joint is proposed for reinforced concrete pressure pipe in diameters of 10 to 48 inches and in lengths

of 12 feet, each section of pipe being provided with cast iron spigot ring at one end and a cast iron bell ring at the other, the rings being cast into the concrete.

The faces of the rings bear upon a lead gasket and are accurately machined providing a very true circular surface. The spigot ring is provided with a seat for the gasket, the object being to provide a greater thickness of gasket at the seat and to prevent the gasket being withdrawn when the pipe contracts or is deflected. The lead gasket consists of a thin lead pipe filled with fiber and is compressed into the space between bell and spigot when each succeeding length of pipe is shoved home. A light rope of cotton or jute is placed and a weak joint filler of cement mortar is applied, filling the caulking space. The joint has remained tight under test at 110 pounds pressure per square inch.

Tanks and standpipes. There are many examples of concrete standpipes of much greater height than 100 feet. The Fulton standpipe at Fulton, N. Y., is 100 feet high to overflow and is 40 feet in diameter. The circular concrete tower and tank at Middleboro, Mass., is 123 feet high. The concrete cylindrical tower and tank of the Central of Georgia Railway at Savannah is 188 feet high.

The supporting tower of elevated tanks may be either of concrete framework or of the cylindrical type. The latter has a number of advantages. The same forms may be used to construct the supporting tower as are used in the construction of the tank. These forms are moved upward as the concrete is being placed, thus giving a continuous monolithic concrete shell without any construction joints whatever. In addition to this particular advantage in construction the cylindrical tower furnished a housing for the riser pipe which protects it from low temperatures and may even be utilized for storage or office purposes.

In the design of concrete standpipes, as in the design of such structures of any material, the critical point is usually found in the junction of the shell with the base. The Fulton tank above referred to is an example of a successful method that has been used to take care of the expansion and contraction at the bottom of a standpipe shell due to variations in water level and temperature. The central portion of the foundation for this tank was constructed higher than the point of contact between the bottom of the shell and the foundation. Thus, space was formed between the inside of the shell and

the central raised portion of the foundation. This space was filled with an asphaltic material. The shell of the standpipe proper was not connected to the foundation but rested on a slip joint which allowed movement at the base of the shell to provide for change in the diameter of the standpipe due to variations in pressure. The

REINFORCED CONCRETE WATER TOWER AND CHIMNEY

top of the concrete foundation on which the shell rests was first covered with graphite paste and sheet copper laid immediately on top. The walls of the standpipe thus rest upon the sheet copper plate which is free to move on the graphite.

This standpipe was constructed with sliding forms and was completed from foundation to overflow in 52 working days. It has been in constant use since 1913 and has proved entirely satisfactory.

Filters. Concrete is particularly useful in the construction of mechanical filtration plants. At the Montebello plant at Baltimore, Md., for instance, about 50,000 cubic yards were used, most of which withstands water pressure or heavy loads. No waterproofing compounds were used in these structures, as good workmanship and materials were relied upon for securing waterproof work. Steel forms were used in the construction of the groined arches and walls and columns but were not found to be entirely satisfactory for columns and arches on account of difficulty in erecting and removing them. The steel forms for walls were entirely satisfactory. It is worth while to note in passing that at the present time steel forms are available for construction of this sort, which add a great deal to the ease with which it can be accomplished and the author feels quite sure that in the design of such a filtered water reservoir at the present time, a flat slab construction would be considered in place of the groined arches and that standard steel forms for columns and slabs would be used.

A feature of the head house of the Montebello filters is the elevated tower 4 feet square and 80 feet high containing the chemical storage bins. This tower has 15 bins which will hold about two carloads of chemicals each.

Pumping stations. The use of concrete in the construction of buildings of a general nature is too well known to need any particular comment. A pumping station, of course, has some special features required by the fact that it houses machinery and boilers. The building best adapted for this purpose is one which will be free from vibration, furnish adequate light and afford security against fire. These requirements are all met by concrete.

An interesting example of pump house construction is that recently completed for the city of Louisville, Ky. This station is located on the bank of the Ohio River just east of the city's old pumping station. As the structure had to rest on sand and gravel and as it was necessary to build the foundation so as not to affect the adjacent buildings, the open dredging well, caisson method was used. The outside dimensions of the caissons are 90 feet square by 33 feet deep, with a bay on the river side 61 by 22 feet and 33 feet deep. The interior cutting edges were 5 feet $2\frac{1}{4}$ inches above the outside cutting edges, thus allowing room for a working chamber in case obstructions were encountered, compelling conversion of the caisson from the open well to pneumatic type. However, this contingency did not arise

and the caisson was sunk to its final resting place without mishap. After filling the dredging wells, the foundation became a solid block of concrete, 90 feet square by 28 feet thick under the main house and 51 by 22 feet by 16 feet thick under the bay. On this foundation the substructure extending to the main floor level was built. This is 83 feet square at the bottom and tapers to 75 feet square at the main floor level, which is 7 feet, 6 inches above high water. The inside of this part of the structure is cylindrical, 67 feet in diameter, and forms the pump pit. The cylindrical pump pit walls were designed to resist external water pressure and the construction has resulted in an absolutely dry pump well.

No concrete shows on the face of the superstructure but back of the 6-and 9-inch ashlar surface is a concrete wall 30 inches thick, which in reality amounts to piers between the high windows and supports the runway girders for a 30-ton crane. Stone facing was used in order to make the new station as much like the old one as possible in external appearance.

Fuel oil tanks. There is now a marked tendency to use fuel oil in the place of coal for the generation of power. There are certainly many advantages to be derived from the use of this fuel. It does away with a considerable amount of the handling expense, leaves no ashes and cinders to be disposed of, and produces but relatively little smoke. Firing with fuel oil is a simple matter and effects economy in labor.

In order that fuel may always be available and that the purchasers of it may have the opportunity to take advantage of market conditions, storage capacity should be provided. The storage of fuel oil has been and is still subject to considerable discussion, especially in regard to the effect that the presence near buildings of such combustible material has on the fire hazard. It is the author's understanding that there is an almost universal practice to add a very heavy penalty because of the presence of fuel oil in open tanks above ground. This penalty, however, is not added when the oil is stored in concrete tanks below ground. There are further arguments for the underground storage tank. Such tanks do not occupy space near the power plant, which is usually needed for other purposes. They are entirely out of sight as well as protected against likelihood of fire from lightning or from other origin.

The design and construction of concrete oil tanks is little or not at all different from concrete water tanks. In fact, it is usual to

design them for ordinary hydrostatic pressures and experience shows that when well constructed, entire confidence may be placed in their ability to hold the oil without leakage. Naturally, where the surface of the tank is level with the ground surface and will have to carry loads, the cover must be designed accordingly and usually requires the use of columns which rest upon the tank bottom.

Actual bids on the cost of concrete tanks reveal the fact that even including the excavation and backfill, they are only slightly more expensive than the usual open surface steel tank. Of course, concrete tanks require no painting and may be considered as permanent and therefore practically free from any cost save first cost.

AIR LIFT PUMPING AND WATER PURIFICATION[1]

By John Oliphant[2]

This paper is not written to discuss the principles of air-lift pumping, but it is advisable to call attention at the outset to the necessity, if success is to be attained, of choosing correctly the diameters of the water and air pipes for different lifts and submergences, and of obtaining a complete, intimate mixture of the air and water at the foot piece. If an air lift plant is properly designed and constructed it furnishes water continuously without interruption for a long period. For example, at Maywood, a suburb of Chicago, there is an air lift plant furnishing 700 gallons per minute from a single well, with a lift of over 300 feet. The compressor has been running twenty-four hours daily for four years, without other interruption than a stop of a few minutes each day for examination and occasionally for some adjustment. There has been no expense whatever for repairs.

There are occasions where the air lift can be used as an auxiliary to a high duty suction plant pumping from deep wells, as at Clinton, Ill., something over a year ago. There the water is obtained by suction from deep wells. For ordinary purposes a sufficient amount is delivered by this method, but for peak loads in the summer and in case of fire the supply was not sufficient. The water is drawn from half a dozen wells having a surface flow of limited volume. These are connected so as to flow into a surface reservoir, or may be direct-connected to the mains by means of suction pumps.

In order to be able to meet the heavy drafts, three of the wells were connected with the air lift system arranged to discharge into the reservoir, using the suction piping as a gravity flow line. One of the 8-inch wells had a natural artesian flow of about 150 gallons per minute. When under suction from the pumps, the pull-down was 20 feet, increasing the flow to 500 gallons per minute. With

[1] Condensed from a paper presented at the Buffalo convention, June 10, 1919.

[2] With Sullivan Machinery Company, Chicago, Ill.

the air lift, its production was increased to 1035 gallons per minute, the pumping head being 50 feet below the surface. The other two wells, connected up in the same manner, showed a proportionate increase.

The efficiency of the air lift when operating under heavy lifts is illustrated by table 1, giving the results of two tests made at Galesburg, Ill., on plants installed by the author. One plant has been in operation for a year and the other about six months. Formerly the public supply was drawn from three deep and six shallow wells, with a combined yield of about 250 gallons per minute. This plant was expensive to operate. It was therefore decided to sink a new well, which furnished 450 gallons per minute, which was so satisfactory that a second well was sunk in another part of the city, which furnished 650 gallons per minute.

Well 1 was cased with 40 feet of 24-inch heavy steel casing, 106 feet of 20-inch, 130 feet of 16-inch, and 350 feet of 12-inch, the last being sealed into the rock. A 12-inch hole was then drilled to a depth of 1085 feet from the surface, where the diameter was reduced to 10 inches and the drilling continued, through the St. Peter's sandstone, to a depth of 1255 feet. It was then shot with two 200-pound charges of 100 per cent gelatin, covering the entire sandstone stratum, and cleaned out carefully. Ten-inch wrought iron pipe was next sealed into the top of the 12-inch pipe about 350 feet below the ground surface; this extends to within 3 feet of the top of the sandstone and keeps out of the well all water from strata overlying the St. Peter's formation. The air lift delivers the water into a small surface reservoir from which it is pumped into the mains under 40 pounds pressure by a centrifugal pump. On account of the heavy lift, an auxiliary starting device was installed at a depth of 481 feet, 8 inches.

The main features of the second well are also shown in table 1, from which it will be seen that this equipment also included an auxiliary starting device.

There is one feature of pumping water by the air lift which gives it special advantages where it is desirable to eliminate certain substances like sulphates or carbonates of iron which are in solution. When the air is thoroughly mixed with the water, the latter is aerated and certain of its undesirable constituents are thereby oxidized into forms which can be removed by filtration.

Carbonates of iron are more susceptible to treatment in this manner than are sulphates of iron. With the latter the water will probably need preliminary sedimentation before it goes to the filters and a small dose of lime may be needed to accelerate the sedimentation.

There are various methods of arranging the parts of one of these combined lifting and purification plants. The air lift may merely

TABLE 1

Results of tests of air lift installations in two wells at Galesburg, Ill.

	WELL 1	WELL 2
Depth of well	1252 ft.	1245 ft.
Diameter of well	40 ft. of 24-in.	360 ft. of 15 in.
Diameter of well	106 ft. of 20-in.	230 ft. of 14½ in.
Diameter of well	130 ft. of 16-in.	635 ft. of 13½ in.
Diameter of well	809 ft. of 12-in.	
Diameter of well	170 ft. of 10-in.	
Water pipe in well	235 ft. of 5-in.	204 ft. of 8-in.
Water pipe in well	331 ft. of 6-in.	213 ft. of 7-in.
Water pipe in well		190 ft. of 6-in.
Main air line	331 ft. of 2½-in.	600 ft. of 3-in.
Auxiliary air line	490 ft. of 1½-in.	500 ft. of 1½-in.
Static head from ground	186 ft.	190 ft.
Drop during pumping	118 ft.	157 ft.
Elevation above surface of outlet	7 ft.	7 ft.
Total lift	311 ft.	354 ft.
Operating submergence	262 ft.	253 ft.
Percentage of submergence	45.8 per cent	41.75 per cent
Depth of pump in well	566 ft.	600 ft.
Operating pressure	121 pounds	115 pounds
Starting pressure with auxiliary	149 pounds	135 pounds
Discharge per minute	450 gallons	650 gallons
Free air used per minute	450 cubic ft.	719 cubic ft.
Revolutions of compressor per minute	179	214
Water horse power	35.5	58.2
Operating air horse power	94	148
Estimated efficiency	37½ per cent	39.3

discharge water from a well into the sedimentation basin of a purification plant from which it is pumped in the usual way. If the well is deep enough to give the necessary submergence and other conditions are right, the air lift can be arranged to lift the water into an elevated tank, which will also serve as a sedimentation basin, from which the water will pass by gravity through a pressure filter

into the water distribution mains. A third arrangement that is practicable under some conditions is to place the pressure filter in the line between the well and the elevated tank.

The practicability of using the air lift for installations like the last two is sometimes overlooked. They are not always possible, for the operating conditions must be right to enable them to be used satisfactorily. In the boosters generally used in these installations, the water discharged from the well is brought to a complete stop by striking what is called an umbrella separator in the booster. This throws the water to the bottom of the booster and allows the air to escape from the top. Nevertheless, owing to the intimate mixture of the air and water, which resembles an emulsion in appearance, considerable air is carried by the water discharged from the booster. While this air is beneficial, on account of its aerating properties, in the purification of the water, it is detrimental if the booster delivers water to long horizontal pipe lines, because the air will form pockets at high points. It is also detrimental where the water goes directly to pumps or condensers. Where such operating conditions exist the air must be removed by a separator.

THE CYCLONE SEPARATOR

In order to overcome the difficulties of carrying air over into long pipes because of complete emulsion and to insure perfect separation of the air and water, a special separator has been designed, consisting of a simple shell or cylinder with top and bottom. The combined air and water is discharged into the top and at one side at a tangent to the periphery, under high velocity from the well, causing it to swirl, effecting in this way a perfect separation of the air and water, the water leaving the separator from an outlet at the bottom tangent to the periphery and the air passing off at the top. The downward centrifugal action completely separates the air from the water, leaving the air quite dry and freeing the water entirely from air bubbles.

AIR LIFT PUMPS[1]

By Chas. J. Deem[2]

It has been charged by some that the manufacturer of air lift pumps wishes to surround his product with mystery. This is not the case. The manufacturers of air lift pumps, like any other trades-people, wish to sell all of their product that they can and will give all the information regarding its operation that will make it more popular in the deep well pumping field. However, they are limited in this desire by the fact that no master formula has as yet been devised whereby infallible rules can be laid down for the proper design and installion of any and all lifts without any regard for the conditions that exist in the wells.

Some fifteen years of experience has taught the author that in many instances wells are just as individual in their actions as are persons. Therefore, a properly designed air lift installation, operating satisfactorily in one well, might give entirely different results when installed in another well which, to an inexperienced operator, might seem to be identical. While experience is not absolutely essential to the pumping of water from deep wells by means of compressed air, yet the author knows of no engineering field where experience counts for more than in air lift pumping.

Contrary to popular belief, the compressed air discharged through an air lift pump does not blow the column of water upward after the first discharge. When the static head is lifted from the working head of the well by the first inrush of air, the water is forced out of the pipe in a solid column. After that, the compressed air passing through the pump reduces the specific gravity of the water in the discharge line of the pump. This consequently moves upward by the expansion of the air bubbles, aided by the greater weight of the solid column of water surrounding the discharge line.

[1] Read before the Iowa Section, October 23, 1919.

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In an economically designed air pump, it is imperative that the formation of large bubbles of air be avoided, for these have a tendency to rush upward without lifting the proper amount of water for the stored energy that they contain. Therefore, the pump should divide the air into small streams or jets, creating as many small bubbles as possible in order to give the best economy. The slip of these bubbles constitutes the chief loss in the energy of the air lift. It is figured that this varies as the square root of the volume of the bubbles. Therefore, the smaller the bubbles, the more efficient the air lift.

One of the foremost things to be considered in installing a pumping plant is its efficiency. Probably there is no one word in the English language that is used more today in manufacturing and engineering circles than "efficiency." The only true way the author knows to figure the efficiency of a pumping plant is that at the end of the year the column in the ledger headed "operating costs" be added up and the results calculated from its total. In this column there will be found items such as repairs, break-downs, and their attendant losses, and it is possible to read between the lines the worry that was caused thereby.

To give some idea of the faith that the underwriters of the country have in the reliability of the air lift system, the author desires to point out, with Mr. Judd's permission, that by discarding deep well pumps and installing air lift systems in the city wells in Mason City, the Board of Underwriters in Chicago granted 30 points on the key rate of insurance for the fire protection which the increased yield of the well would afford the city, and they gave 130 points because of the reliability of an air lift pumping system.

Some years ago the author installed an air lift in a flowing well on a ranch in southwestern Texas. The well was 8 inches in diameter, about 600 feet deep and flowed about 20 gallons a minute. The owner of the ranch had only a small compressor, its maximum capacity being 30 cubic feet of compressed air per minute. A 6-inch pump was installed, and these 30 feet of air delivered to it. The head of the well dropped 20 feet from the surface and the well yielded 530 gallons per minute, accurately measured over a knife-edged weir. Of course, this was phenomenal. Never before or since has the author seen such a small volume of air deliver so much water from a deep well.

A few weeks ago, at Fort Dodge, Iowa, a 6-inch pump was installed in a flowing well on an island in the Des Moines river. The well was 8 inches in diameter, 500 feet deep and flowed 21 gallons per minute. The same size pump was located 200 feet from the surface and 200 cubic feet of air were delivered to it. The working head of the well dropped 150 feet from the surface and yielded 80 gallons per minute. This proved to be a very uneconomical installation. Yet to all outward appearances, the conditions in the second well were the same as those in the first mentioned. In this second well experience would have been necessary to have properly readjusted the piping, had the city decided to use it. However, there was plenty of other water available, so the well was abandoned. But an air lift could have been installed in it, which figuring from the current input at the motor of the compressor to the water discharged in the reservoir, would have shown 30 per cent efficiency. This could have been obtained by installing a 3-inch air lift and taking 50 per cent submergence, or, in other words by placing the lift as far below the working head of the well as it was desired to lift the water. This would have yielded 1 gallon of water for 0.63 cubic foot of air at 67 pounds pressure. Of course, the starting pressure in this well would have been greater than that of the other wells of the system, yet this would have been offset by the use of an auxiliary air line to lift the head off the well. Had the original installation in this well been let stand, any one wishing to speak disparagingly of air lift pumping could have, in all honesty, cited it as an expensive mode of pumping water. On the other hand, some manufacturer, wishing to extol the virtues of his pumps, might honestly print a glowing advertisement of the results obtained in the well first described. Both would be equally misleading.

It has been stated that an air lift system requires little or no attention outside of keeping the compressor in proper running order. While this is practically true, yet there are times when the system becomes unbalanced and the working head of the wells recedes, which changes the percentage of submergence, thereby reducing the yield of the well and increasing the amount of air required. If conditions at the wells are checked up once or twice a year, and changes made to meet the new conditions, a great deal might be saved in operating cost at times. Not so long ago the author was called to a plant where a battery of five wells was pumped from one compressor. The compressor at its maximum speed was barely

large enough to pump the amount of water required. The operator said that when the plant was first installed it gave excellent results, but there had been a decided falling off in the yield of the wells. The system had not been installed by the company the author represents, but it was well designed and should have given good results. Upon investigation, it was found that two of the wells were much weaker than the other three, and that they operated at about 15 pounds less pressure than the other wells. When the engineer had balanced up the system, he had set the regulating valve at the well heads of these two weaker wells so as to admit only enough air to pump the water that they would economically yield, and, of course, had left the valves wider open on the strong well. When starting the system, the operator discovered that many times these two weak wells did not come in. In order to overcome this he had opened the valves of these weaker wells. Any force follows the line of least resistance and the larger part of the volume of air from the compressor rushed into the weaker wells where it could not lift the amount of water that it could have done in the stronger wells. Therefore, this system was out of balance and giving poor results, through no fault of the air lift or the man who installed it.

A great many mistakes are made, when installing air lifts, in reference to the size of the pump to be used to deliver a certain volume of water. For instance, if it is desired to lift 150 gallons per minute from a well with a working head 80 feet below the surface, the most economical pump to be installed here would be a 3½-inch lift at 65 per cent submergence. Under these conditions, this pump should yield 1 gallon of water for every 0.3 cubic foot of air at 67 pounds pressure. The pump would be located 229 feet from the surface. Now suppose, instead of being able to get 65 per cent submergence, it is possible to get only 40 per cent submergence. In order to deliver 150 gallons per minute under these conditions, a 4½-inch pump should be used and we may expect a gallon of water for every 0.59 cubic foot of air at 25 pounds pressure. It will require 1.1 more horse power to raise the water in the second instance than in the first. As the submergence decreases, the size of the discharge line should increase. But this is only a general rule and the conditions in the well to be pumped wholly govern the ratio of the change to be made.

Of late years some engineers have been advocating a variable discharge line. They wish to start with a smaller pipe and expand

toward the point of discharge, the theory being that by allowing the compressed air more space in which to expand, it will lend more of its energy toward lifting water. On the other hand some engineers advocate turning this type of installation upside down, as it were; that is, they reduce the diameter of the line toward the point of discharge, the theory being the same as the reason for choking the muzzle of a rifle in order to keep all the gases behind the bullet until it leaves the barrel. Of the two systems, so far as observation has gone, the latter is to be more preferred. The author has seen it produce excellent results under some conditions, that is, by furnishing more water with greater economy than would be possible with a uniform discharge line made of standard pipe sizes. Probably the friends of the expanded discharge line system will challenge this statement and point to some installations they claim are great successes. The author has seen one or two of these but they have been invariably installed in excellent wells that yielded large quantities of water very economically, not because of the system of expanding the discharge line, but in spite of it.

Another improvement in the air lift system that should be mentioned briefly is what is known as the booster pump. This is a tank located on the well top. It automatically separates the air and water as they are discharged from the well, and retains just enough pressure from the separated air to force the water to the point of discharge. This is a great improvement when the water must be transferred long horizontal distances toward the point of discharge. Hitherto when horizontal distances had to be considered, unless the water was delivered to an elevated tank and allowed to flow from it by gravity, the air would get ahead of the water in the discharge line, thereby materially reducing the efficiency of the system.

EMERGENCY FIRE PROTECTION CONNECTIONS TO MUNICIPAL WATER SYSTEM AT HARTFORD, CONN.[1]

Due to evidence of pollution in the Hartford water supply, the cause of which was located in a small auxiliary connection used for industrial purposes between the city system and a driven-well supply, an order was issued by the Board of Water Commissioners to separate physically all connections between the city mains and other sources of water supply. This order included the auxiliary fire connections. Several of the manufacturing establishments having fire connections controlled by the double check valve system protested against this order. During the discussion, the fact was clearly shown by records that there was leakage through the checks on many test inspections; frequently through one and on several occasions through both valves at the same time. At this meeting an expert representing the manufacturing and insurance interests stated that while there was some danger in any connection of a public supply and a polluted source and that, as a general rule, health officers and practical water works operators were opposed to such connections, nevertheless he believed that such connections could be made of little danger if controlled by a properly designed check valve system. He stated that the present design was not satisfactory, the chief difficulty being that there was danger of corrosion or binding of the hinge and of pipe moss becoming wedged under the valve seats. He suggested that these difficulties could be largely done away with by the construction of a bronze valve differing somewhat in detailed construction from that at present in use. The expert would not admit that even such a valve would be absolutely without danger but believed that the danger of pollution would be so reduced that it would be of less importance than the dangers to life and property resulting from insufficient fire protection. A request was made by the manufacturers that the order of the Board be suspended pending an endeavor on their part to design a more efficient check valve and this request was granted by the Board. Such a design has been submitted.

[1] Memorandum furnished by the Editor.

It is practically a duplicate of the present Factory Mutual check valve. It is, however, made entirely of bronze instead of having a cast-iron body with bronze clapper and seat. It has certain other modifications, all of which are in the interest of improvement in mechanical efficiency. Among the advantages claimed are:

1. The gasket is moulded from the choicest and toughest of rubber, such as is used for the treads of the best tires and in a mold possessing mechanical accuracy so as to insure perfect seating with a minimum of pressure, such as the weight of the clapper.

2. The hinged carrier which controls the clapper as to position when seating is made so as to permit of a wabble of one part with the other within certain limitations, and at the clearance points, the parts are properly shaped for machining so as to guarantee the necessary clearance at all times, whether the pressure be light or heavy, thus permitting the gasket to seat with uniform pressure throughout. The gasket is held by a single plate locked at its center, which serves to dovetail the rubber at its holding point.

3. The hinge is also arranged so as to favor the action, and the body of the valve so shaped as to permit lifting the clapper upward and out of the body of the valve for inspection, rendering the renewal of the gasket an easy matter if necessary, although it is claimed to be doubtful if they will show serious wear or deterioration for a period of twenty years, as the freedom from frost, heat or light and the presence of water are all favorable for long life to good rubber.

4. Below the clapper there are greatly increased clearances for the washing away and out of the valve of foreign materials such as gravel.

The approval of this valve will involve the acceptance of the following conditions by the Board:

1. A connection exists between a badly polluted stream and the public water supply.

2. This connection is controlled by a mechanical device.

3. Valves of substantially the same pattern but of probably less efficient mechanical construction have shown leakage in the past.

4. Little or no difference in insurance rates is made for factories protected by the double check valve system or for those protected by suitable tanks or cisterns.

5. The previous valves now condemned were, when installed, probably alleged and expected to give perfect protection.

6. If approved, the burden of responsibility in case of typhoid outbreak must rest upon the Commission, which is now building new works at very heavy expense to give an unquestionably pure supply to the city.

WATER WORKS FOR FIRE PROTECTION[1]

By H. F. Blomquist[2]

The functions performed by water works may be considered as being three distinct services: (1) To furnish water for private use. (2) To furnish water for public use on streets and for sewers, public buildings, etc. (3) To furnish water for fire protection to property.

It is the aim of this paper to discuss some features that are often abused or neglected in connection with the fire protection service, calling attention to some principles of design of water works plants that should be observed in order to furnish a satisfactory fire protection service, and some statements in connection with the value of this service, and methods used by various municipalities for paying for it.

Amount of water for fire protection. From time to time during the past twenty-five years, standards for the amount of water required or desirable for fire protection have been suggested by different engineers. One of the first was John R. Freeman in 1892; later Allen Hazen and others in 1897; and the National Board of Fire Underwriters in 1910. Each of these gives formulas for determining the amount of water required for fire protection, and uses the number of inhabitants served as a basis for such calculations. The value of such formulas, however, may vary in different communities, because there is no fixed relationship between the population and the amount of water necessary to successfully put out a fire in the various communities. What may be good fire protection for one community of a given number of inhabitants, may not be for another of the same number of inhabitants because of the difference in construction of structures, nature of industries, and density of industrial sections, etc.

[1] Read before the Minnesota Section, May 3, 1919. Discussions of this paper are requested and should be sent to the Editor.

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A statement of the formulas proposed by these men may be of interest. According to John R. Freeman, in 1892, the total quantity of water required in gallons per minute equals 250 times $x/5$ plus 10 where x equals the number of thousands of inhabitants. According to Allen Hazen, in 1897, the quantity equals 700 times the square root of x, where x equals the number of thousands of inhabitants. According to the National Board of Fire Underwriters in 1910, the quantity equals 1020 times the square root of x multiplied by one minus 1/100 times the square root of x. These formulas vary somewhat, one from the other, but give an indication of what is considered a sufficient quantity of water that should be available for good fire protection.

Under the National Board of Fire Underwriters formula, the following figures give the required number of gallons per minute that should be available, 1000 population, 1000 gallons; 2000 population, 1500 gallons; 4000 population, 2000 gallons; 6000 population, 2500 gallons; 10,000 population, 3000 gallons; 13,000 population, 3500 gallons; 17,000 population, 4000 gallons; 22,000 population, 4500 gallons; 40,000 population, 6000 gallons; 80,000 population, 8000 gallons; 100,000 population, 9000 gallons; 125,000 population, 10,000 gallons; 150,000 population, 11,000 gallons; 200,000 population, 12,000 gallons. Over 200,000 population, 12,000 gallons per minute, with 2000 to 8000 gallons additional for a second fire. It is also desirable that the pipe system be of such design as to provide at least one-half of this amount for any one block of buildings, and in a greatly congested value district, the whole amount should be available for any one block.

Relations of the different parts of a plant. In order that proper results for fire protection may be obtained from the water works system it should be so designed that the maximum efficiency is obtained from all factors that enter into the furnishing of the water. Each of the following factors should have the proper relationship to the whole system: Source of supply, pumping equipment, reservoir or storage capacity, water pressure, distributing mains and the location of hydrants. Each of these is a link in a chain that supports the fire department in its efforts to put out a fire, and this support is no stronger than the weakest of the links. If the reservoir is of large capacity but the pipes are small, much of the cost of the reservoir is practically wasted. If the hydrants are not properly spaced the advantage of large distributing mains is to a considerable extent

lost. The spacing of hydrants and sizes of hydrant connections are very important in attaining high efficiency of a system for fire service.

Water pressure. The water pressure in the mains is of greatest importance if fire engines are not used, because a stream under heavy water pressure is very much more effective than one under low pressure, even though the same amount of water may be used on the fire. Unless water is applied to burning materials in buildings at a high velocity much of it does not reach the seat of the fire because of the difficulty of access and draft from burning gases. It is, then, either evaporated or decomposed into the two elements, hydrogen and oxygen, a part of which in turn combines with carbon of the burning materials and forms inflammable gases, which again burn. The water that does not reach the burning material is of little value, if any, and when transformed into gases may even be an aid to the flames rather than a means of putting them out.

In order to be of most value a fire stream must have a velocity that can be obtained only from a good pressure at the hose nozzle. As little as possible of the available pressure should be used up in hose and water system friction. It is, therefore, important that hydrants and mains should be of such sizes as to decrease as little as possible the water pressure at the hydrant nozzle by friction in the pipes, hydrants and connections during the time of heavy flow.

Friction in hose. The amount of pressure lost by friction or resistance in fire hose is a considerable item and varies very nearly as the square of the velocity or quantity of water flowing through. A few examples of the effect of this are shown by the following facts regarding the discharge of various lengths of 2½-inch rubber-lined cotton fire hose attached to a hydrant which has a constant pressure of 60 pounds at the hydrant nozzle. When a 1½-inch stream flows from a smooth bore nozzle with 100 feet of hose, it is possible to throw a stream of 250 gallons per minute 67 feet high; with 200 feet of hose this is reduced to 222 gallons per minute thrown 59 feet high; with 400 feet of hose it is reduced to 188 gallons per minute thrown 44 feet high; with 700 feet of hose it is reduced to 158 gallons per minute thrown 33 feet high, and with 1000 feet of hose it is reduced to 140 gallons per minute thrown only 25 feet high. It is, therefore, important that hydrants be spaced quite closely together in parts of towns and cities that are occupied by business or industries where fires are apt to be of a serious nature, in order that all available pressure may

be utilized in fighting the fire. There is a large waste of power in pumping all the water against a 60-pound head and getting only about 25 pounds effective pressure at the nozzle of a long line of hose.

The friction of water in fire hose is very often neglected. Long lines of hose are laid where short ones could be used and the water department sometimes is blamed for not maintaining a good water supply under proper pressure when the fault lies in poor judgment in locating the proper hydrants on which to make connections, and using much longer lines of hose than are necessary in reaching a fire. Of course, there are conditions where long lines of hose are absolutely necessary, but these conditions should be overcome as as much as possible by placing additional hydrants.

Reservoir capacity. The relation between the size of storage reservoir, pumping machinery, and source of supply must necessarily vary with local conditions, and for a well-balanced system a certain inverse ratio should exist between these factors. If it is possible to have a reservoir at an elevation to give the desired pressure and with a capacity sufficient to care for the heaviest fluctuations in the amount of water used for all possible emergencies, the pumping machinery and source of supply need not be of greater capacity than to safely take care of the average supply with a fair factor of safety, but if it is impossible to provide large storage of water for emergency uses, the water supply and pumping machinery must have sufficient capacity to furnish the required quantity during the time of the emergency. The possible size of the reservoir is affected generally by topography, and the desired capacity is governed by the facilities for pumping and the size of the available water supply.

The effect of the topography upon the design is often to change the reservoir from what is desirable to what is feasible. In a comparatively flat country it is impossible to store as much water as is desirable at a high elevation and in such cases the distributing reservoir must be reduced in size and other portions of the system, such as the available supply and the size of pumps, must be increased so as to do the work which should properly be done by the distributing reservoir.

For example, in a perfectly flat territory, where an elevated tank is the only feasible form of reservoir, it will at most be only a means of making it possible to store a part of the water that will be necessary for large fires, and, therefore, the main water supply must be

provided by pumping during the time of fire. In such a case it is necessary to have a supply and pumping capacity sufficient to furnish nearly all the water that will be required for fire protection at the time of the fire. If wells are used as the source of supply in such cases, a storage reservoir at a low elevation where it is convenient to build one, will serve as a suitable supply base. Where the topography is such that it is feasible to build a reservoir of any desired size and at proper elevation, the capacity is dependent almost entirely upon the requirements for fire protection.

The pressure furnished by the reservoir should be such as to give the required quantity of water at the proper pressure for fighting fires, and as this depends also on the size of the pipes, the pipe sizes and the reservoir pressure have a certain relationship one with the other and must be considered together. The cost of pumping water against a high pressure must also be considered in the design of reservoir and mains. Generally it is found that from 80 to 100 pounds per square inch is the most economic available pressure at points where there is likely to be the greatest demand for water. The elevation of the reservoir necessary to obtain this pressure will depend to a large extent upon the distance from the reservoir to the center of distribution and on the size of mains used.

The maximum desirable pressure is a matter on which there is much disagreement. For direct hydrant streams the National Board of Fire Underwriters recommends a pressure of at least 75 pounds at the hydrant when the water flows from it at its rated capacity, except that where not more than ten buildings exceed three stories a residual pressure of 60 pounds is permissible. In closely built residential districts a residual of 60 pounds is considered sufficient for direct hydrant streams, with 50 pounds in thinly built sections of low height. Where fire engines are used they recommend that the pressure on the full flow should not drop below 20 pounds, except a minimum pressure of 10 pounds is permissible under certain conditions. In small cities it is generally economical to maintain, if possible, a pressure of from 50 to 100 pounds in the system and thereby not require the use of fire engines for good fire protection. In large cities, instead of pumping all the water against the heavy pressure, it is more economical to maintain a lower pressure in the mains and to use fire engines to create the high pressure fire streams.

As stated before, the size of the reservoir must necessarily depend upon local conditions but should be, if possible, large enough to

hold at the required elevation, in addition to the domestic supply for 24 hours, a sufficient quantity of water with which to fight any fire that is likely to occur. A fire in the built-up portion of a small city may take from 1000 to 5000 gallons per minute, and in general the time during which this quantity will be required will not be more than from two to four hours. Applying this rule to the ordinary small city where there are no large fire risks the capacity of the reservoir or stand pipe should be from 120,000 to 1,500,000 gallons. During the time the water is being drawn from the reservoir it will also be possible to run the pumps, which will provide additional water, the amount of which will depend on their capacity. In all cases it is important that the water mains be of such sizes as will furnish the required amount of water at the desired locations during the time of heaviest flow with a reasonable amount allowed for friction loss.

Sprinklers. In this paper no mention has been made of water supply for automatic sprinkler systems in buildings. Although automatic sprinklers are very important as a means of fire protection, the amount of water required for them is not very large, and does not constitute very much of the total amount required for all purposes. Such systems are rather a means of reducing the amount of water necessary for proper fire protection by helping to keep the fire under control until the fire department arrives, and sometimes by extinguishing it entirely.

Maintenance and reserve capacity. In addition to the proper design of a water works plant it is of utmost importance that the mechanical equipment, fire hydrants, gate valves and other appurtenances, be maintained at a high state of efficiency so as to be reliable and always ready to perform their proper functions. There should be a thorough and systematic method of inspecting all equipment with special emphasis on fire hydrants in freezing weather. Pumps and engines or motors should consist of at least two separate units, each of sufficient capacity to take care of all requirements, so that if one unit is out of order on account of breakdown or repairs, the other unit will be able to furnish the required amount of water.

Value of fire protection. The fire protection service performed by the water works as well as its other functions, should have its just share of the operating expenditures balanced by operating receipts. In order to strike such a balance, the value of this service or the cost of furnishing it must in some way be determined. Many standards

for determining the value or cost of furnishing fire protection have been used by various municipalities, and in many instances it has been neglected altogether. In order to arrive at an equitable basis for determining such value, it is necessary to consider the difference in the design and operation of a system necessitated for the purpose of furnishing fire protection.

In a large city the requirements for fire protection do not play as large a part, relatively, in the design of a system as they do in a small city, except in certain details, such as fire hydrants, the size of mains, and, to some extent, the capacity of the pumping equipment, because in a large city the requirements for private and public use are usually very large, and constitute the greater portion of the total capacity that must be provided. In smaller cities, except the source of supply, as far as construction is concerned, the fire protection requirements determine nearly all the important features and include the pressure to be maintained, the size of the storage reservoir, the size of mains, and the pumping plant. These portions of the plant could be made much smaller and much less expensive were it not for the fire protection requirements.

The portion of the entire physical property of a water works plant involved in fire protection has been estimated by competent authorities to be as high as 80 per cent. The National Board of Fire Underwriters estimates that the percentage of cost of a distributing pipe system, chargeable to fire protection service for various size cities, is as follows: One having 10,000 population, 56 per cent; 50,000 population, 29; 100,000 population, 17½; 300,000 population, 4. Of the entire cost of the plant chargeable to fire protection service the estimate is as follows: 10,000 population, 60 per cent; 50,000 population, 32; 100,000 population, 23; 300,000 population, 13. Other authorities have given higher proportions as the cost of this service, especially for larger cities. The investigation of the cost of furnishing fire protection to a section of Greater New York for a population of about 400,000 people using an average daily supply of 38,000,000 gallons of water served by a private water company, showed that only 3 per cent of the total investment and 15 per cent of the operating expenses were attributable to fire protection, but with allowance for depreciation and interest on investment, the cost of fire protection was found to be approximately 21 per cent of the total cost of furnishing water by this company.

Metcalf, Kuichling and Hawley, in their paper[3] on "Reasonable Return for Fire Hydrant Service" make this statement:

> The cost of the portion of the water works plant involved by fire protection service probably constitutes from 60 to 80 per cent of the entire cost of the property in the case of communities having less than 5000 population, 20 to 30 per cent in communities of 100,000 population, more or less, and perhaps 10 to 20 per cent in case of our large cities.

It is certain that the cost of furnishing fire protection constitutes such a large part of the total cost of the plant, and the value of the water works share in furnishing this protection is of sufficient importance to warrant special attention by municipalities.

For fire protection the amount of water consumed is very small, therefore, the value or cost of the service cannot be measured by the amount of water consumed, but must be derived from the cost of the additional construction and equipment required, and the maintenance of such additions. That part of the water works plant chargeable to fire protection consists of the additional pumping capacity, increased size of water mains, larger storage facilities, and the cost of hydrants. The approximate cost, therefore, of fire protection consists of the following items: The interest on the additional investment necessary in the water works plant by reason of the increased amount of construction required as stated above, and the maintenance of this portion of the plant. Also a certain amount of the attendant and inspection charges necessary in order to have the plant ready for operation at all times, day or night, which otherwise would not be necessary, especially if sufficient storage is provided for the ordinary consumption.

A conception of the value of fire protection service may also be obtained by comparisons of fire insurance premium rates under efficient fire protection and under no fire protection. This protection is made up of a fire department together with the water supply provided for this purpose, and the water works share of it consists of providing the agencies necessary for furnishing an additional amount of water under proper pressure over and above that necessary for the ordinary consumption, and the value of the water works part in it bears the same proportion to that of the fire department as the cost incurred by the water department in furnishing this service, bears to that of maintaining the fire department. The

[3] PROCEEDINGS, American Water Works Association, 1911, page 66.

difference in the insurance rates, however, is not the only value of good fire protection. There are other factors, such as the effect of economic waste resulting from loss of business, income and wages in the reconstruction following the fire, and the loss of property that cannot be replaced.

There are various methods used by municipalities in paying the water company or the city water department for its share of this service. A common method is to pay a monthly or annual hydrant rental of a fixed amount for each hydrant installed. While this method cannot be considered sound from either a business or technical standpoint, it is perhaps the simplest way of paying something for the service. There are valid objections to this method, one of these being that the number of hydrants used multiplied by a stipulated amount does not represent the cost nor the value of the service, but perhaps the greatest objection to it is that it will tend to prevent the installation of the proper number of fire hydrants required for good fire protection in order to save on the annual hydrant rentals. It is believed that a more desirable method of paying would be an annual lump sum based upon the cost of the service to the water company or city water department, and upon condition that the city should control the location and number of hydrants to be maintained. This lump sum should be revised from time to time in order that it may be equitable, and provide for additional service as the system is enlarged. There should be no objection, however, to dividing this amount by the number of hydrants in use, and calling it hydrant rental, provided the number of hydrants were not to be reduced below the requirements for good service.

Acknowledgment for data used in this paper is gratefully made to Messrs. Goodman, Metcalf, Kuichling and Hawley, and others from whose reports data have been used.

AN EXPERIENCE WITH A BROKEN 24-INCH WATER MAIN[1]

By S. L. Etnyre[2]

Before describing a recent experience with the blowing out of a 24-inch main, its history and importance in the operation of the plant must be explained. This main was laid on Broadway in 1882, running from the Broadway pumping station at 37th Street to 21st Street, a distance of 8500 feet; from this point to 8th Street there is 5323 feet of 20-inch, thence to the high level storage reservoirs 5200 feet of 16-inch. Up to 1915 all the water for the city was supplied through this 24-inch pipe. On account of the importance of this main and owing to the fact that with increased consumption the pressure materially increased, it was found necessary to lay an auxiliary 16-inch main from the Broadway station to 21st Street, and this was completed in 1915. With the reservoirs' storage it was calculated that the 16-inch would supply the city in the case of any mishap to the 24-inch. Two 24-inch valves were cut in the Broadway main and a drain laid into the sewer from the main at its lowest point.

In 1884 the Broadway main broke at 30th Street, a section 12 by 24 inches blowing out at the bottom. No flaws were noticeable. In 1908 this main broke at 28th Street; a triangular section 18 inches at the base and 6 feet long blew out at the side. No flaws were noticeable. In 1909 on the west side of 34th Street the pipe broke as if pulled apart. No flaws were noticeable.

The normal pressure carried by this pipe was 105 pounds. On October 6, the last break took place on the east side of 34th Street, a 12-foot section splitting on its side its entire length. The pressure chart taken at the pumping station shows that the pressure dropped suddenly from 125 to 17 pounds. The volume of water escaping through this break was enormous, resulting in the drop of pressure

[1]Read before the Iowa Section, October 23, 1919. Discussion of this paper is requested and should be sent to the Editor.

[2]Superintendent, City Water Works, Council Bluffs, Iowa.

all over the city; and many parts, even at moderate elevations, were without water until the valves were closed. From measurements taken at the high-level reservoir, making allowance for the normal city consumption, over 1,000,000 gallons had run out through this break. Fortunately, however, there was no material damage to private property.

The chart also plainly shows the time of closing the valves. Some time was lost in this work by the breaking of a 24-inch valve stem. Pumping to the city through the 16-inch main was started immediately upon the closing of the valves. The drain valves into the sewer were then opened, and when the pipe was broken into it was found to be entirely free of water. It is also remarkable that all valves proved to be water-tight. The defective section was broken up with sledges, and replaced with a new length and the main ready for service within fifteen hours from the closing of the valves. During the time the repairs were being made less than 1 per cent of the consumers of the city were without water, and but for the breaking of the valve stem above referred to less than one-half of 1 per cent would have been without water.

An examination of the pipe along the line of fracture showed that the original coating was well preserved and that at one point there was a casting defect. A careful examination of the fracture, however, does not warrant the assumption that this condition prevailed to any extent. The thickness of the shell along this line was a good average with the rest of the pipe, being approximately 1-inch. The question that now naturally suggests itself is, "What is the reason for this break?" Of course, the water pressure was partly responsible, but it is not the complete answer. The pressure chart shows that it was not caused by "water hammer." The thickness of the shell seems adequate for the pressure it has to carry; it is a good grade of metal and there are no evidences of serious flaws on the fracture line or elsewhere when broken into small pieces.

SUBSTITUTES FOR LEAD IN JOINTS[1]

By Thomas Healy[2]

At the Council Bluffs meeting of the Iowa Section a paper was read[3] regarding a material used by the Omaha water works in the place of lead for making joints in water mains. Afterwards, by courtesy of Mr. Howell, a visit was made to Omaha where an opportunity was given to see some joints poured with metalium and observe the result of turning the water pressure immediately thereafter on the mains having these joints. The advantage of metalium joints seemed to be that the material was cheaper per joint than lead. Not so much fuel was needed to melt it as was needed to melt lead. The bell holes required were not so large and no calking was needed. The disadvantage seemed to be at the time that greater care was necessary to melt metalium than lead because if too cold it would not pour and if too hot it became stiff and might burn.

No way by which a joint which leaked could be made tight was apparent and the author did not have the nerve to act on the advice of the users, who said that if it was left alone the leak would stop of itself. The author had no previous acquaintance with that kind of a leak. Finally, as the war went on, the cost of lead went up, and the Government continued to request that metals should not be used, the Davenport Water Company decided to try out metalium for joints in some mains it was laying for the U. S. Housing Corporation. This corporation was building several hundred houses to help relieve the situation caused by bringing several thousand additional families to Davenport, Rock Island and Moline, to help turn out material of war at the Government Arsenal situated at this point. These mains were required at once, and it was found possible to lay them more quickly when no calking was required.

In using metalium in Davenport it is customary to join three or four lengths of pipe before lowering them into the trench. The pipe

[1] Read before the Iowa Section, April 16, 1919.

[2] With Davenport Water Company, Davenport, Iowa.

[3] Journal, American Water Works Association, June 1918; page 174.

are laid on sticks across the ditch, lined up and leveled, and, after pouring the joints, are lowered by two pipe derricks using rope slings. No trouble seemed to result from handling the pipe after the joints were poured. The metalium joint takes a little longer to cool than lead, especially the gate, which is made large to insure filling the joint.

The Davenport Water Company started out cautiously in this work. It used the special furnace furnished by the metalium manufacturers and all the tools they have developed. The manufacturers agreed to send an expert to oversee the pouring of the first joints, but the work was started before he arrived and his only help lay in saying the work was done well. Some of the pipe to be laid was 12-inch and lead was used for this size. The first line using metalium was 6-inch pipe and this line was bottle-tight when tested. The next 6-inch pipe laid developed two or three leaks and it was decided that these leaks were due to carelessness, for the pouring seemed so easy the men neglected to clean the pipe in the joints or to make the gates high enough to insure a full joint. As soon, however, as the men became as careful as at first there was no further trouble.

Nine or ten pounds of lead are usually employed at Davenport in pouring a 6-inch joint and it was found that 3 pounds of metalium would make a joint of the same size. At that time lead was 8 cents and metalium 10 cents per pound so the material in the joint cost us about three-eighths as much as lead would have cost. Lead, however, is much cheaper now than it was at that time.

When using lead a kerosene oil furnace is employed which requires about 25 gallons of oil to keep it going all day. The number of joints poured in a day varies widely, so the cost of oil varies, as it is not practical to let the lead furnace cool off but the flame is kept going whether little or much lead is melted. With the furnace used for metalium only wood is needed and it is possible to "borrow" a piece here and there, which furnishes the small quantity required.

It is evident that, there being no work to do in the bell hole except to put on and take off the jointer, very little space is required. At first jointers were used up rather rapidly and probably more jointers are needed than are required for lead. However, by soaking the jointer in water and smearing it with clay, it lasts longer than formerly.

Metalium is easy to handle and there has been no trouble in having orders filled promptly. In one or two instances old joints that have

caused trouble by lead blowing out have been poured with metalium and these joints hold well so far.

In 1918, the company laid 9,155 feet of pipe with metalium joints and so far it has laid nearly as much in 1919, and expects to continue to use it until something better develops.

In 1917, the company laid 424 feet of 6-inch pipe with leadite joints and this has given no trouble of any kind since laying. The methods and cost of using leadite were not very different from those in the case of metalium.

SOME TROUBLES WITH ALGAE IN THE SKANEATELES WATER SUPPLY OF SYRACUSE[1]

Syracuse, N. Y., obtained an average supply of 24,741,000 gallons a day from Skaneateles Lake in 1918. This lake is about 14 miles long and 1 mile wide, with a water surface of about 15 square miles. The tributary watershed is approximately 60 square miles and has a permanent population of about 3000, which is increased to about 4250 in summer. There is no large tributary to the lake and the greater part of the watershed has been cleared and devoted to agriculture.

The examination of the watershed made in October, 1919, by E. S. Chase, assistant engineer of the State Department of Health, showed that the sanitary conditions were satisfactory, in general, for a populated area. The rules and regulations for the sanitary protection of the watershed and the lake, prescribed by the Department in 1907, were found to be rigorously enforced. The watershed is patrolled daily, and the entire area is covered about once a fortnight. There are about 270 summer cottages along the shore of the lake. These have privies provided with removable containers, the contents of which are removed at regular intervals by city employees and buried on city land about half a mile from the head of the lake. The sewage of the village of Skaneateles, at the foot of the lake, is treated in a septic tank and the effluent from this tank can by no means reach the lake.

The Syracuse water department has installed a chlorinator at the gate house, to which the water is brought through a 64-inch intake pipe from an intake crib in 40 feet of water. The chlorination

[1] On page 149 of this number of the JOURNAL there is a note by Mr. Brush on the treatment of the Catskill water supply of New York City by copper sulphate. The very large amount of water to be freed from algae makes it necessary to conduct the treatment with more attention to detail than has usually been given to such work. Similar treatment was recommended in November, 1919, by Theodore Horton, chief engineer of the State Department of Health of New York, for the Skaneateles supply of Syracuse, and these notes on the subject have been prepared by the editor from Mr. Horton's official report.

apparatus is operated only at intervals and then solely to see that it is ready for use in case of emergency. In view of the use of the lake for boating and the comparatively large number of persons along its shore during the summer, Mr. Horton believes that there is a sufficient danger of the contamination of the water to warrant the continuous operation of the apparatus.

Some trouble has been experienced with tastes and odors due to algae growths during the early summer. Whether these organisms develop exclusively in the lake water and are transferred to the reservoir in the city, not developing in the latter, or whether temperature and other conditions are responsible for growths within the reservoir itself, Mr. Horton could not decide with his present knowledge. If the algae growths are due fundamentally to growths in the lake water it was recommended that an attempt be made to apply copper sulphate to the supply. In conjunction with this the aeration of the supply as it enters the city reservoir was also recommended for study.

Owing to the fact that the reservoir contains only some five days' supply and that the ordinary method of applying copper sulphate is at best somewhat crude with reference to proper distribution, Mr. Horton suggested that desirable uniformity of distribution might be accomplished by the application of the copper sulphate at the screen chamber at Skaneateles lake. This would give an opportunity for uniform distribution and for a long contact period and, possibly, for partial sterilization by the bactericidal action of copper sulphate.

THE WATER DISTRIBUTION SYSTEM OF INDUSTRIAL HOUSING PROJECTS FOR SHIPBUILDERS[1]

By William H. C. Ramsey[2]

Of the many industrial activities undertaken by the government and occasioned by our forced entry into the world struggle, in the interest of humanity and right, none stands more prominent than our wonderful record in the building of ships. Late in the fall of 1917, following the decision of the government to build a veritable bridge of ships across the Atlantic Ocean, the United States Shipping Board, Emergency Fleet Corporation, was organized and its accomplishments have become history. Scarcely had the necessary legislation been enacted, before contracts were negotiated and consummated, to adequately fill the demand for ships for the transportation of our troops and equipment and of supplies for our allies, as well as our magnificent army. In order to meet this demand for ships and to promote rapid accomplishment, many existing shipyards were expanded and many others were created new.

The larger and established yards are located in sections where other industrial growth had already produced a congested population, while the smaller or newer yards are situated near small communities, where the demand created for shipbuilders far exceeded any previous provisions for housing or transporting American workmen. The former condition is notably illustrated in the Delaware River district, the Clyde of America (fig. 1), where, prior to the war, the industry produced more ships than any other district in America. It was natural that these yards, so wonderfully equipped, should be the first to be expanded. Other industries in this section had previously enlarged their plants and greatly increased their forces to meet the war demands of the Allies, and as a result of this influx of workers, the demand for houses created a congestion of serious

[1] Read before the Buffalo Convention, June 12, 1919. Discussions of this paper are requested and should be sent to the Editor.

[2] Designing Engineer, Engineering Branch, Housing Department, Division of Passenger Transportation and Housing, Emergency Fleet Corporation, Philadelphia.

nature. Men slept, as well as worked, in three shifts and men with families could not even find livable quarters, not to mention satisfactory or suitable ones, in the vicinity. It was immediately evident that transportation and house construction were vital elements in the prosecution of shipbuilding. Accordingly in December, 1917, a housing department of the Emergency Fleet Corporation was established under the Division of General Service, with J. Rogers Flannery of Pittsburgh as executive head.

The early activities were concerned chiefly in studying housing conditions in the vicinity of the shipyards, their adequacy and the means of securing maximum occupation. It was soon realized, that additional housing development was urgent and also, that much relief could be attained through a betterment of transportation, so

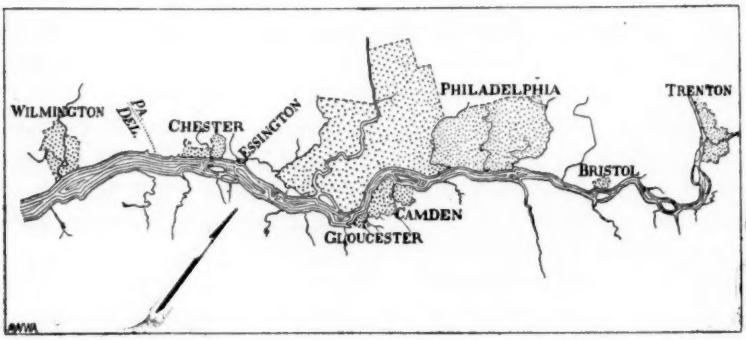

FIG. 1. PART OF DELAWARE RIVER CALLED "THE AMERICAN CLYDE"

that families could be housed at some distance from the yards and carried to their work by trolley and train. The scope of the work necessitated a larger organization and on April 3, 1918, the Passenger Transportation Service Section was established, under the same executive head, to study, develop and extend the available systems of transportation and to improve and increase the service.

Under an act of Congress approved March 1, 1918, $50,000,000 were appropriated and the United States Shipping Board, Emergency Fleet Corporation, was authorized and empowered to purchase, lease, requisition or otherwise acquire and to sell or otherwise dispose of, improved or unimproved land, houses and buildings, and for other purposes. This appropriation was later increased to $75,000,000. under an act approved July 1, 1918, which provided for appropriations for sundry civil expenses.

Under the Housing Section designs were completed and contracts let during April and the early part of May, 1918, for housing projects at Hilton, Newport News, Va.; Hog Island Dormitories, 94th Street and Tinicum Avenue, Philadelphia; City of Camden, N. J.; Yorkship Village, Haddon Township, Camden County, adjoining Camden, N. J., and St. Helena, Md.

On May 7, 1918, the Housing Department and Passenger Transportation Service Section were merged into the Division of Passenger Transportation and Housing under A. Merritt Taylor, Director. The activities of this branch of the Fleet Corporation have since continued under this Division and since February 1, 1919, J. Willison Smith has been executive head with the title of Manager.

The jurisdiction of the Division included:

1. The determination upon and establishment of such necessary measures as would relieve the difficulties in passenger transportation and deficiency in facilities of transportation companies serving the various shipyards that hold contracts with the Emergency Fleet Corporation.

2. The determination of housing developments required to expedite ship construction, and the designation of character of houses and the establishment of same.

3. The securing of necessary land, property, franchises and facilities required for the above purposes, by purchase, condemnation or other means.

At the same time that the Division of Passenger Transportation and Housing was established, an additional sum of $20,000,000 was appropriated by Congress for transportation purposes only.

ORGANIZATION OF HOUSING DIVISION

The Housing Department of the United States Shipping Board, Emergency Fleet Corporation, under an executive head designated first as Director and later Manager, functioned through a Production Bureau, composed of an administration section and three major divisions; the Branch of Design, which handled the town planning and architectural features, the Engineering Branch, which regulated the design of utilities and street improvements, and the Construction Branch which supervised the construction of the complete building and utility program. Morris Knowles of Pittsburgh was chief engineer of the Engineering Branch and it is largely due to his effort

and skill that the program for municipal improvements and utilities was so successfully accomplished.

The first step in the promotion of a housing development is that of investigation into the need for housing, the available sites and the character, type and cost of houses and utilities.

Investigations and planning. Under the work of the Emergency Fleet Corporation, a shipbuilding company files a formal application for housing in the vicinity. An investigation committee is appointed, comprising usually a representative of the Property Branch, which conducted the negotiations for the acquirement of land and for the extension of the facilities of the local utility companies, and representatives of the Production Bureau, including a town planner, an architect and an engineer. This committee verifies the information submitted and makes a thorough investigation of the site, its location, accessibility and topography, looks into the facilities of the local utility companies and the municipalities, and submits a full detailed report, with recommendations. It frequently occurs that the report is a negative one, either as relating to the site itself or to the necessity for housing.

After it has been determined to proceed with the housing program and the site has been accepted and the number and character of houses determined upon, the Branch of Design, through a town planner, develops and presents a general layout. In the meanwhile, the Engineering Branch takes up its duties in the design of municipal improvements and utilities, coöperating with the town planner, so as to conform the town layout to the economical construction of municipal improvements.

Needless to say, with the large housing program which was undertaken, it was impracticable in the limited time and with an organization which would not be unwieldy, to handle the details of design for all the projects from a central office. The Division of Passenger Transportation and Housing, with its underlying branches, therefore acted as a central organization or a clearing house, which regulated the design and through which all designs had to pass for approval. Each local project was represented by a town planner, an architect and an engineer, who were appointed by the respective branches of the central organization. Their qualifications, organization and past record in the prompt expedition of work and in the management of large undertakings were carefully investigated and governed their appointment. The engineer on this work was designated Local

Project Engineer. The Engineering Branch supervised the work broadly comprehended by the terms "municipal and utility engineering." Instructions for the preparation of plans and standards of design were prepared and submitted to the retained or local project engineers, who were directed to prepare plans for the approval of the Engineering Branch.

Water supply investigations. Immediately after the site was selected, a complete investigation was made of all convenient sources of water supply. Investigation was made and assurance received that the water was clear and free from sediment at all times, did not contain any objectionable mineral constituents, and was entirely safe from a sanitary standpoint. Before reaching a decision upon the purity and potability, studies were made of past health records, typhoid rates, water analyses, and any other pertinent data and evidence that could be obtained and would lead to a conclusion. It was insisted that the supply should be abundant and wholesome, even though extensive changes in local practice and standards were necessary.

Alternative studies were made, either for extending the existing private or municipal systems or for obtaining water from an independent source. An intimate knowledge of the local water supply and distribution system, therefore, had to be gained, before definite plans for the introduction of water into a project could be devised. In order to expedite the installation and to keep the cost low, efforts were made to obtain ample supplies, not only for the domestic but for fire protection purposes through a gravity system. It was usually found, however, that the supply lines had to be reinforced and the source of supply strengthened to meet the requirements of quantities and pressures, although, in most instances, the location of the projects was such that existing facilities could readily be extended to meet the demands. Where the pressures were insufficient, consideration was given to booster stations, elevated storage tanks and portable fire fighting equipment, and a decision was rendered on the basis of initial cost, maintenance and operation.

In all cases, provision was made for good circulation by the use of a gridiron system, with all dead ends eliminated. Very careful attention was given to economical layout, not only in the determination of pipe sizes, but in the arrangement of valves and hydrants. The character of service pipe and the methods of installation were adapted to local practices, but a $\frac{3}{4}$-inch service was adopted as the

minimum permissible size. All services were provided with curb cocks.

General water supply requirements. General requirements for quantities and dependability of supply were governed and fixed by the type and size of the development and the character, size and grouping of the houses. In the printed instructions issued to the Local Project Engineer, certain governing considerations were set forth for his guidance, with stress laid on available quantity and quality. In the determination of quantity, the consumption of the additional population to be supplied was rated at 100 gallons per capita. As a guide in determining the supply required for fire protection, the instructions suggested that it should be computed on the basis of million gallons per day equivalent to the square root of the population in thousands. For instance, if the population to be housed was 9000, the allowance for fire service would be at the rate of 3,000,000 gallons per day, in addition to the average domestic consumption.

It was also stipulated that no pipe smaller than 6 inches in diameter should be used in the distribution system, although it was recognized that 4-inch pipe could be used for a cross-connection in a residential street where there would be no future necessity for placing a hydrant. As regards quality, the standard of purity, as previously indicated, was to be adhered to, and studies for the introduction of water were based on this information. The pressure standard was also indicated, and while it was appreciated that the housing development was largely residential, high business or other public buildings might occur in the future; and instructions were issued to provide fire protection capable of being increased, if future growth so demanded. A minimum of 40 pounds was placed as the lowest desirable domestic fire pressure, with pressures of 50 to 60 pounds where possible, and even higher pressures in special locations. Where the desirable pressures, through extensions of the municipal or private systems, did not obtain, the Local Project Engineer was to arrange for a means of temporarily raising the pressure to 60 or 70 pounds; with 80 to 100 pounds as the minimum desirable for business districts. Provision was made for the proper fire pressures and quantities through ample pumping machinery and sufficient suction storage, and by elevated tank or reservoir of adequate capacity.

Cast iron pipe was generally specified for the distribution system. Wood stave pipe was to be considered for long lines or large pipe in

special cases. Steel pipe was to be avoided, as this material was so badly needed for other war uses. Hydrant spacing was stipulated, so that pressure losses through fire hose were kept at a minimum. The usual setting was to place the hydrants at intersections, except in long blocks, where an intermediate hydrant was to be placed. A normal spacing of 300 feet was requested, with 400 feet as a maximum. In layouts, where the sub-division was not uniform, it was required that the hydrants should be placed so as to cover 90,000 to 100,000 square feet of territory.

Figure 2 shows the cross-sections taken at several of the housing projects, and is introduced to show the variations in the location in streets and alleys, of water and gas mains, sewers and electric pole lines.

It was stipulated that valves should be liberally used and so placed that ordinarily not more than three blocks of pipe would be thrown out of service when control valves were closed. Large mains up to 18 inches in diameter should have valves from $\frac{1}{4}$ to $\frac{3}{8}$ mile apart. All pipes connected to larger mains should be valved, and smaller pipes, 4-inch to 10-inch, should be valved at least every $\frac{1}{4}$ mile. Valves on hydrant branches were to be omitted, except where the main was 10 inches or larger, or where local practice had to be followed.

It was specified that house service pipe under all highways should be best quality, extra strong lead pipe, laid from main to curb cock. The extension of the lead pipe into the dwelling was recognized as being desirable and preferable. Under warranting conditions, galvanized lead-lined pipe or galvanized pipe could be used. Great weight in determining the class of material that would have a reasonable life under local conditions was laid upon local practice and the experience of the local water works companies.

A general policy of metering was adopted by the Housing Department, with the meter installed either at the curb in frost-proof boxes or in the cellars, dependent upon local conditions.

The necessity for water supply and fire protection was created upon the inception of building construction and the demands grew daily with the increase in the force of workmen and with the growth of building construction and consequently the fire hazard. In many cases, the construction of new supply lines and the installation of booster pumps and other additions for storage of supply were required and could not be readily installed, on account of delays in the delivery

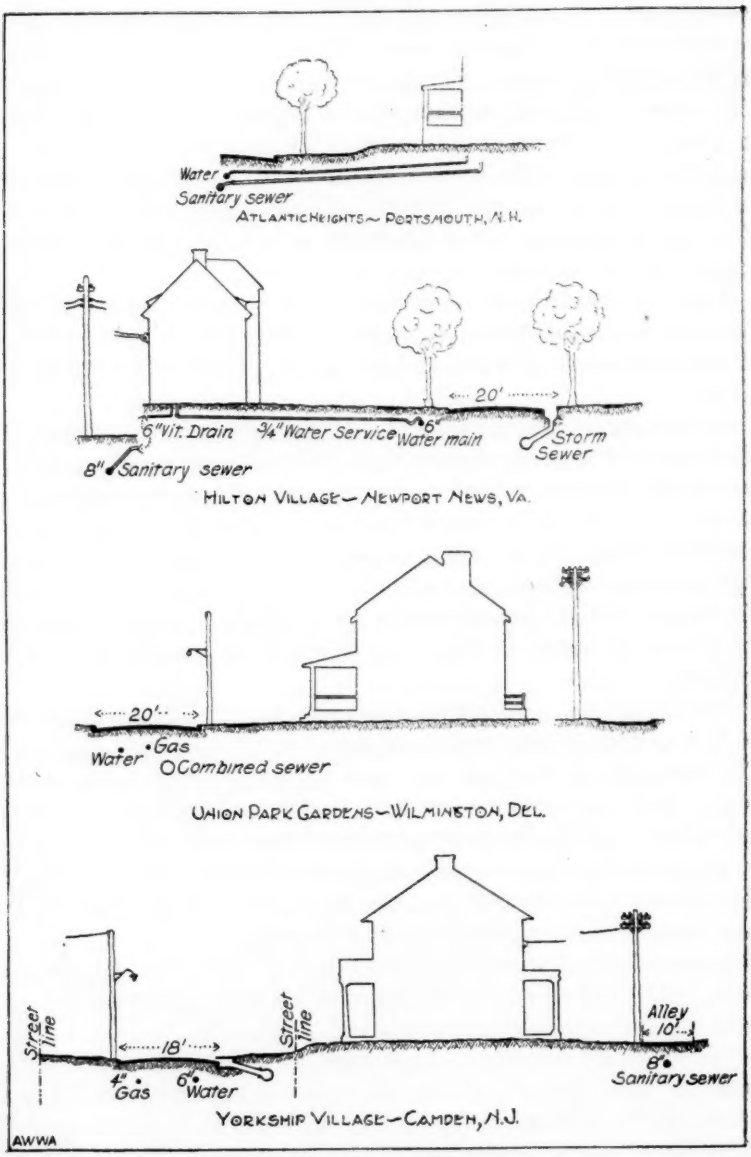

FIG. 2. VARIOUS LOCATIONS OF UTILITIES IN HOUSING PROJECTS.

of materials. It was, therefore, necessary to make temporary provision for fire protection, in advance of the complete permanent installation. So far as possible, the permanent distribution system was laid very promptly and immediately thrown into service; while in other instances portions of the permanent system were completed and connection made with a temporary system laid upon the ground. The extent of the temporary distribution system was determined by the size of the project, the location of the building construction and by the proximity of a water supply ample for construction and fire protection purposes. It frequently occurred that temporary supply lines were laid on the surface and connected with the existing terminals of the municipal or private systems and occasionally temporary booster stations were provided.

Promptly after the authorization for the construction of a housing project, negotiations were entered into by the Property Branch with the municipal authorities or private company, for the extension of its plants and facilities. Financial assistance by means of loans was rendered when necessary.

The Engineering Branch coöperated with other divisions of the Emergency Fleet Corporation and, in the determination of quantity and pressure of water for fire protection purposes, was constantly in touch with the Fire Protection Section of the Shipyard Plants Division. This section was supervised by representatives of the National Board of Fire Underwriters. The Engineering Branch also coöperated with the Insurance Section of the Finance Division under which there was a Fire Branch. This section looked into and placed insurance on all buildings connected with the housing projects.

As soon as the Local Project Engineer presented his preliminary layout of the water distribution system and his supporting data, a conference was immediately called for the determination of the minimum requirements of quantity and pressure. In these conferences, representatives of the departments previously mentioned were in attendance. From studies of the character and type of houses, their arrangement and grouping, pressures and quantities, proximity of fire fighting apparatus and the possibility of its installation on the project, after thorough discussion, a conclusion was reached regarding the necessary quantities and pressures for the particular project and what provisions, if any, should be made for increasing the pressures. The distribution systems were examined not only from an engineering standpoint but also from the point of view of the Board of Fire Underwriters and the insurance companies.

AUTHORIZED PROJECTS

In all a total of 24 projects were authorized and of these 19 were constructed under the direct supervision of the Passenger Transportation and Housing Department. Under the complete program 28,064 shipyard workers can be housed and the number of employees at the yards affected by the housing is about 150,000. In magnitude, the projects range from 42 houses at Groton, Conn., and 79 houses at Wyandotte, Mich., to approximately 1900 at Camden, N. J. The average is about 250 houses. Table 1 gives a list of the constructed projects, and their geographical location.

The apportionment of houses for shipworkers' use and the number of persons for whom accommodations are provided include:

	persons
8644 houses and 2 boarding houses	43,459
849 apartments	4,245
94 dormitories	6,174
5 hotels	1,430
Total	55,308

The estimated cost of the projects is about $70,000,000 and of this amount, approximately one-fourth to one-fifth is required for the construction of street improvements and public utilities.

WATER DISTRIBUTION SYSTEMS

Bath, Maine. The project is located in the northern part of the city, within the city limits and on the western bank of the Kennebec River. The water is obtained from the Bath Water Department.

Originally, it was planned to develop a system for a delivery rate of 1500 gallons per minute, but afterwards this was reduced to a delivery of 1200 gallons per minute, at 54 pounds pressure, to the limits of the project. The distribution system is designed to deliver 1000 gallons per minute, under a hydrant pressure of 47 pounds. The city fire pumping equipment is available for use on the project.

The water mains in this section of the city were very small, and in order to secure the deliveries as above stipulated, under the required pressures, an existing 4-inch main was replaced with a 12-inch main 1900 feet long and connected into an existing 10-inch

TABLE 1

Constructed housing projects of the Emergency Fleet Corporation

PLACE	BUILDINGS	PERSONS HOUSED	SOURCE OF SUPPLY	FIRE SUPPLY	HYDRANTS	
					Number	Gates
				gals. min.		
North Atlantic District						
Bath, Me.	109 houses 4 dormitories	290	City	1200	12	Yes
Portsmouth, N. H.	278 houses 9 dormitories	965	City	1000	19	Yes
Groton, Conn.	92 houses 7 dormitories	433	Borough	1000	18	No
Newburgh, N. Y.	127 houses 70 apartments	374	City	1200	17	Yes
Port Jefferson, N. Y.	9 houses 1 dormitory	224	Private	500	4	Yes
Delaware River District						
Hog Island, Pa	16 dormitories	2042	City	2000	22	No
Essington, Pa.	200 houses 1 dormitory	400 641	Private* Private*	1000 500	11 3	Yes Yes
Chester, Pa.						
Sun Village	430 houses 56 apartments	860	City	1500	22	No
Sun Hill	282 houses	568	City	1000	13	No
Buckman Village	278 houses 22 apartments	876	City	1500	20	No
Chester Hotel	1 hotel	292	City	City	6	Yes
Wilmington, Del.	503 houses 7 apartments	1020	City	1500	32	Yes
Camden, N. J.						
1st Haller	100 houses	200	City	City	10	Yes
Morgan Village	92 houses 1 apartment	190	City	City	10	Yes
Yorkship Village	906 houses					
Fairview Extension	480 houses 4 apartments 1 hotel	3312	City	1500	106	Yes
Gloucester, N. J.	447 houses 1 apartment	896	City	1500	36	No

TABLE 1—*Concluded*

PLACE	BUILDINGS	PERSONS HOUSED	SOURCE OF SUPPLY	FIRE SUPPLY	HYDRANTS	
					Number	Gates
				gals. min.		
Chesapeake Bay District						
Newport News, Va.						
Hilton Village	473 houses	946	Private	1500	26	No
Washington Apartments	4 apartments	421	Private			
Dundalk, Md	529 houses	1100	Private	1500	34	No
	2 boarding houses		Private			
St. Helena, Md	296 houses	1848	Private	1500	17	No
South Atlantic District						
South Jacksonville, Fla.	158 houses	316	City	1500	18	No
Great Lakes						
Lorain, Ohio	232 houses	480	City	1500	18	Yes
	8 apartments					
Wyandotte, Mich	79 houses	158	City	1000	7	No
Manitowoc, Wis	100 houses	500	City	1500	8	No
	1 dormitory					

*Fire protection of the Essington Dormitories is furnished by the industrial water works of the Westinghouse Company, which is able to furnish 500 gallons a minute at 30 pounds hydrant pressure or 1000 gallons at 22 pounds.

main, with lateral feeds of 4-inch and 6-inch. On the project, the 12-inch main branches into three short 8-inch mains, and all other mains are 6-inch.

Portsmouth, N. H. The project is located within the city limits on the Piscataqua River, about 1 mile upstream from the business center, and ½ mile from the main highway between Portsmouth and Dover.

The water supply is taken from the city. The connecting main between the project and the city is small and would not permit of the requisite delivery of 1000 gallons per minute in addition to the domestic consumption. Furthermore, the location and elevation of the project in relation to the city is such that at times of excessive draught in the city it was feared that the water would not reach the project or, possibly, would be drawn from its distribution system. It was, therefore, concluded to provide independent storage

on the tract and to install a motor driven centrifugal pump on the supply line at a lower elevation in the city. A steel tower and tank of a capacity of 100,000 gallons and a height of 100 feet was erected on the high ground to the southeast. The distribution system is designed for a delivery of 1000 gallons per minute with a normal pressure of 40 pounds, but a delivery of 1500 gallons per minute can be obtained by the use of fire fighting equipment with a reduction in pressure to 10 pounds.

An 8-inch main from the tower and tank is carried through the central street of the development to the public circle, at the northern extremity. All other street mains are 6-inch.

Groton, Conn. The project is located in a sparsely settled area, tributary to Groton and New London. The water supply is obtained from the Borough of Groton, which is improving the works. Under improved conditions, there can be delivered through the distribution system a fire flow of 1000 gallons per minute under a pressure of 35 to 40 pounds at the hydrant. An 8-inch main is carried on the north and west boundary streets, and all other mains are 6-inch.

Newburgh, N. Y. This project is located within the outlying section of the city.

The water is obtained from the city, which is planning improvements of its works. In order to obtain a satisfactory supply, it was necessary to reinforce the city gridiron system by the installation of an additional section of distribution main and the enlargement of a section of small main. The distribution system was designed for a delivery of 1200 gallons per minute under hydrant pressure of 45 pounds, although this delivery cannot be obtained until the contemplated improvement in the water supply is made and a large supply main is constructed to the site.

Port Jefferson, N. Y. This project is located in the southern section of the village of Port Jefferson, on the northern shore of Long Island. Water supply is obtained from the Port Jefferson Water Company. The design of the distribution system contemplates the delivery of 500 gallons per minute under pressure of 44 pounds at the hydrant, through a 6-inch main to the site. All water delivered is measured by a detector meter placed on the branch main to the dormitory. It was desired to have a second supply main, but it was felt that the expense did not justify the installation.

Hog Island, Pa. This project is located in southern Philadelphia about ½ mile from the Hog Island Shipyards and just west of the junction of the Schuylkill and Delaware Rivers.

The water supply is taken from an existing 12-inch city main, augmented by what is termed a 48-inch express main, laid into the district immediately after the construction program at Hog Island Shipyard was started. Pressures in the district prior to the installation of the express main were 27 pounds, and after the installation of the main, 44 pounds. The distribution system was designed for fire flows of 2000 gallons per minute, with minimum hydrant pressures of 20 pounds, on the basis that fire fighting apparatus would be used. All piping is 6-inch, and three connections were made to the 12-inch main. The supply to the buildings is metered through one meter for each group of four dormitories.

In this section of the city many houses, providing accommodations for 3978 men, were built under the direction of Admiral F. T. Bowles, Assistant General Manager of the Emergency Fleet Corporation.

Essington, Pa. This project adjoins the turbine plant of the Westinghouse Electric and Manufacturing Company, at Essington, Pa., along the Delaware River, about 4 miles from Chester and 8 miles from Philadelphia. Two projects were constructed, one known as Essington Dormitories, one known as South Philadelphia project.

Domestic water supply for both projects was obtained from the mains of the Springfield Consolidated Water Company, which had previously been laid in Essington and Lester. From this system there was available at the site a static pressure of 60 pounds, yet, on account of the small mains, a fire draught of only 500 gallons per minute at a pressure of 42 pounds at the hydrant could be obtained. By reason of the growth in this district of the many industries engaged in the war emergency, the facilities of the water company were entirely inadequate. A loan was arranged with the United States Housing Corporation by which the water company reinforced its system by the addition of a large main, and it is estimated that 1000 gallons per minute can be delivered at a pressure of 42 pounds.

The distribution system was designed for flows of 1500 gallons per minute at a minimum hydrant pressure of 20 pounds, on the basis that fire fighting apparatus would be used and provided. An 8-inch main leads along the southern and eastern boundaries of the development, and all other mains are 6-inch.

Fire protection for the Essington Dormitory was furnished from the plant of the Westinghouse Company, and connection made to a 20,000 gallon tank on a 75-foot steel tower. The supply is taken from the Delaware River and pumped into the tank without treatment. An 8-inch main leads from the tank and passes centrally through the dormitory tract, while 6-inch branch mains supply the sprinkler system and hydrants. The system will deliver 500 gallons per minute at 30 pounds at the hydrant, 750 gallons per minute at 26 pounds, or 1000 gallons at 22 pounds.

Chester, Pa. There are four projects here; two for the Sun Shipbuilding Company, which for all practical purposes can be rated as one project, as they lie on either side of the Baltimore & Ohio Railroad and are located in the eastern section of the city, and two for the Chester Shipbuilding Company, one known as the Chester Hotel adjacent to the Chester Shipbuilding Company and one known as Buckman Village, located on the western boundary of the city.

Sun Village. The distribution system consists of a 12-inch main through the most westerly streets of the project, with an 8-inch loop line extending eastward into the central streets. All other mains are 6-inch. In order to secure adequate deliveries from the existing city distribution system, a 12-inch main 1600 feet long was laid. In most parts of the project a fire flow of 1500 gallons per minute with hydrant pressures of 40 to 45 pounds are obtainable, but in one section only half this quantity at 35 to 40 pounds is available.

Sun Hill. This project is supplied through an 8-inch main extended from Sun Village.

The distribution system will yield deliveries of 1000 gallons per minute under pressures of about 40 pounds. In both of these projects the city will furnish fire fighting apparatus, which is stationed about $\frac{3}{4}$ mile west of Sun Village. The mains are adequate to deliver 1500 gallons a minute under these conditions.

Buckman. The supply is taken through a 12-inch pipe from a 12-inch existing main about 550 feet north of the project. This feed enters the northwest corner and divides into 8-inch and 6-inch, with an 8-inch main extending through the central street of the project and tying into an existing 8-inch main at the southern border. There are two short runs of 8-inch main extending westward from the central 8-inch main. The valving of distribution

main will not put more than two hydrants out of service for any shut-off. The system is designed for deliveries of 1500 gallons per minute under hydrant pressures of 45 pounds.

Wilmington, Del. The project is located in the southwestern section of the city, and was incorporated through the extension of the limits of the city. The water supply is taken from the municipal system. The distribution system is taken from existing 12-inch mains on the north and east boundary streets. An 8-inch loop main is carried on the south and west boundary streets, and an 8-inch cross main leads through the central portion of the project. All other mains were 6-inch. The design contemplates a delivery of 1500 gallons per minute, with pressures of 40 to 45 pounds at the hydrant. At this project it is worthy of note that the size of the distribution system presented by the city water department was reduced, and smaller sizes placed in practically all streets.

Camden, N. J. The housing developments at Camden consisted of four projects. Two, the first Haller and Morgan Village, are located within the city limits. Two, Yorkship and Fairview Extension, were located originally in Haddon Township, about ¾ mile south of the city limits. In reality Fairview Extension is an extension of the Yorkship project, and both were later taken into the corporate limits of the city of Camden.

The supply for Yorkship Village was taken from an existing 24-inch city main through a 20-inch main about 9200 feet long to the project at the central square, as shown in figure 3.

Fire fighting equipment is available from the city of Camden, and a new fire station is under construction in the southern limits of the city immediately north of Yorkship Village. It was concluded, that with fire apparatus available, there should be delivered 1500 gallons per minute at 20 pounds pressure, in addition to the draught for domestic consumption. The 20-inch main will deliver at 20 pounds at the central square, but with such low pressures available, it was not possible to obtain this delivery on the outskirts of the village. On the western border 1050 gallons can be delivered and on the southern border 1500 gallons, at 10 pounds at the hydrant.

The problem of water supply for this development has not been permanently solved, as future draught upon supply lines, together with the fact that there is some doubt regarding the future quality of the water with respect to foreign matter, may require considerable modification in the adopted plan of supply, and may involve, at some

future time, aeration, filtration and pumping. The water in this district contains much iron, which oxidizes rapidly upon exposure to the air and causes a deposit in the distribution system.

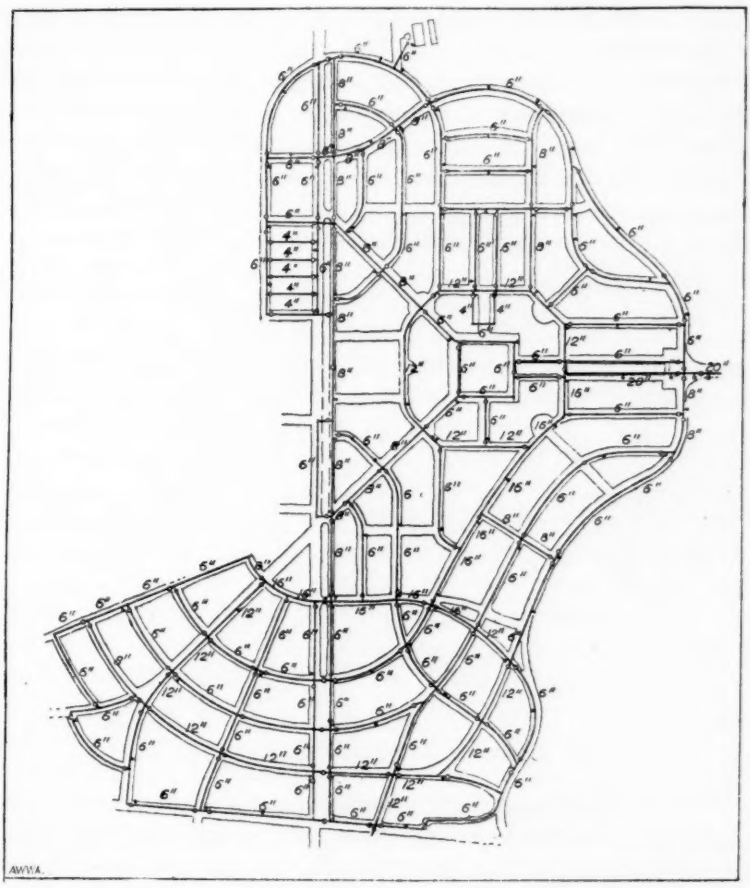

FIG. 3. DISTRIBUTION SYSTEM, YORKSHIP VILLAGE, N. J.

The question of water supply during construction was a serious one, and was temporarily cared for by a connection to the supply main of the General Water Supply Company, in Collingswood, and was brought in, over the surface, in screw joint pipe, and carried across the center of the project to the western end, where building construction was advancing most rapidly. A design for temporary

gridiron distribution system, with connections for fire protection, was developed for the entire project, and was provided for by using 2 to 4-inch screw joint pipe, laid on the surface. Permanent installation in the western portion of the project, where the greater number of houses were under construction, was expedited so as to confine, as far as possible, the laying of temporary lines to the eastern portion. As soon as the permanent mains were laid and tested, they were thrown into service, so as to secure the benefits derived from larger quantities of water, and to replace the temporary system already installed. The installation of the permanent

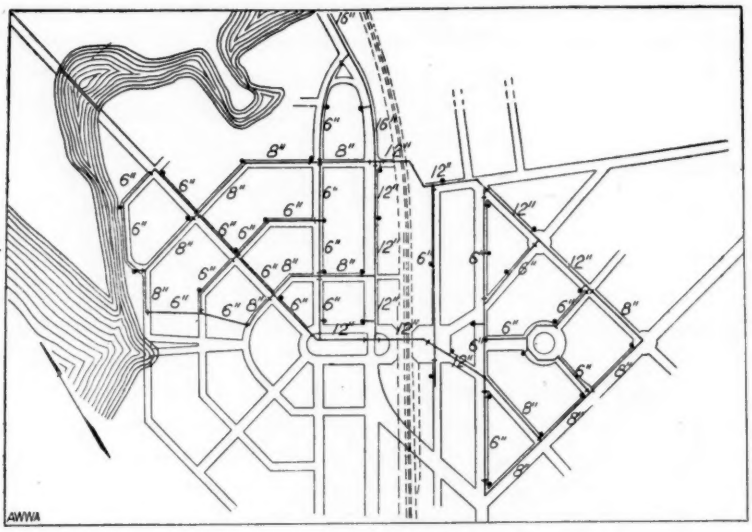

FIG. 4. DISTRIBUTION SYSTEM, GLOUCESTER, N. J.

distribution system progressed rapidly, and soon covered an area beyond that occupied by houses under construction, thus eliminating the requirement for the temporary water line. To provide for heavy drought during short periods and to afford more uniform pressure in the distribution system, a temporary wooden tank of 25,000 gallons capacity was erected on a 75-foot tower and connected directly to the supply main. A small storage was thereby provided for fire purposes.

Gloucester, N. J. This project, figure 4, is situated south of the city limits on a peninsula between two branches of Timber Creek, and the water supply is obtained from the municipal plant of the

city. In order to secure adequate quantities and pressures, it was necessary to lay an independent 16-inch main, 7000 feet long, between the Gloucester pumping station and the project. Connections were so arranged at the pumping station, that the domestic consumption could be cared for by the existing supply facilities. Fire protection can be furnished directly through this main by a high pressure pump, which is to be installed in the pumping station and held in reserve for this purpose.

The distribution system is designed to yield a fire flow of 1500 gallons per minute, in addition to the domestic consumption, with minimum pressure at the hydrant of 80 pounds and with a pressure of 100 pounds at the pumping station.

The 16-inch main is carried into the northern limits of the project, where it divides into two 12-inch mains, which extend southeastward and are looped together by an 8-inch main. Two 8-inch mains extend into the western side of the project and are connected by 6-inch cross mains; all other mains are 6-inch.

A temporary supply of water for building and fire protection purposes was obtained through a temporary main connected with the facilities of the Newbold and Westville Water Company. Screw joint pipe was laid over the surface of the ground, and as rapidly as permanent mains were constructed, they were tested and placed in service, thereby replacing the temporary water system.

Newport News, Va. The housing program at Newport News included two projects, one known as Hilton Village, located on the eastern shore of the James River about 3 miles from the city, and the other project, the Washington Avenue Apartments, in the city. The supply is obtained from the works of the private company which were greatly extended by the War Department.

The water supply for Hilton Village was taken from an existing 18-inch cast iron supply main, which passes the site. Pressures on the main at this point approximate 40 to 50 pounds. A centrifugal booster pump capable of delivering 2000 gallons per minute at a pressure of 80 pounds was installed on an 8-inch branch line leading from the 18-inch main. This pump is driven by a gasoline engine.

The distribution consists of a 12-inch main with 8-inch loop lines extending around the project and through the central highway. The cross mains are 6-inch.

Under the design 1500 gallons per minute can be delivered at any point on the project, under pressure of 50 pounds at the hydrant with pressure of 80 pounds at the booster station.

Dundalk and St. Helena. These two projects are contiguous and are divided by an electric railway from Baltimore to Sparrows Point. They are about 3 miles from Sparrows Point and 6 miles from the center of Baltimore.

On account of the isolation of the projects an independent water system had to be developed, although in St. Helena a water system comprising deep wells, pump, elevated tank and distribution system

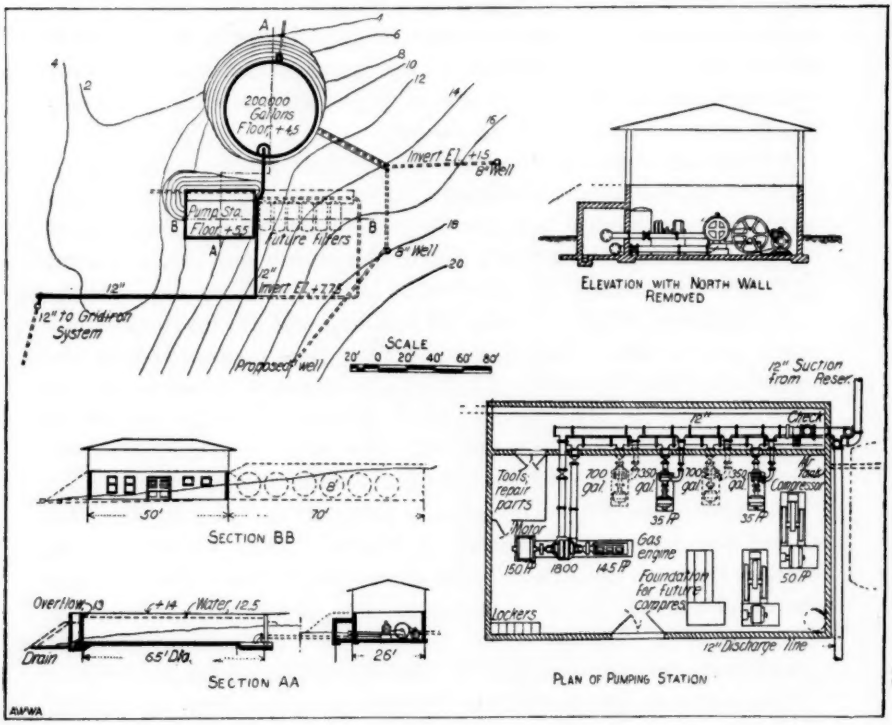

FIG. 5. PUMPING STATION, ST. HELENA AND DUNDALK, MD.

made up of 3 and 4-inch mains had been developed. This supply served admirably during construction and was augmented by laying screwed pipe over the surface and by the addition of fire hydrants, set temporarily. The facilities of the St. Helena plant were entirely inadequate as a source of supply and could not be developed and extended. It was, therefore, decided to secure the permanent supply from a point about 4000 feet from the developed area and a company was specially organized to install and operate the plant.

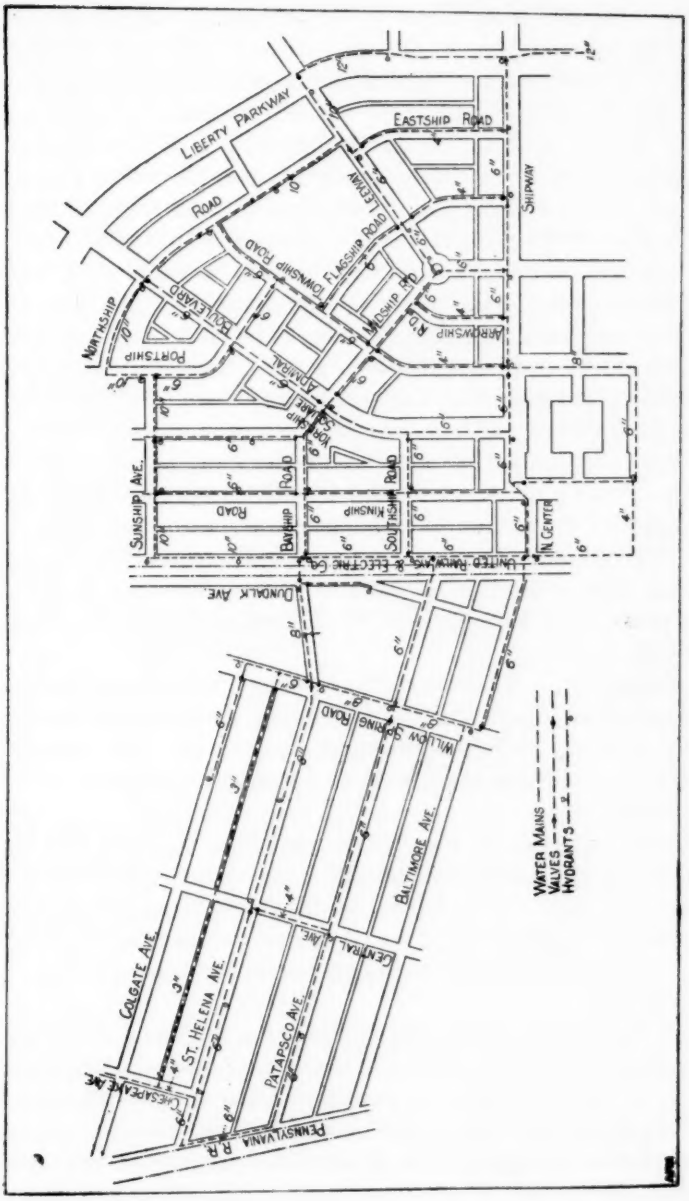

FIG. 6. WATER DISTRIBUTION SYSTEM, ST. HELENA AND DUNDALK, MD.

Water is secured from driven wells, pumped by air into a concrete receiving reservoir of 200,000 gallons capacity, from which it is pumped by motor-driven centrifugal pumps through a 12-inch supply main to the projects. The station equipment, figure 5, comprises duplex domestic service pumps and a direct connected fire pump, arranged to be driven either by electric motor or gasoline engine. Pressure filters may be installed in the future if necessary.

The distribution system, figure 6, is designed to deliver 2000 gallons per minute under a minimum hydrant pressure of 20 pounds. The 12-inch force main enters the developed Dundalk area at the east and is reduced to a 10-inch main, which traverses the northern section and extends southward to a point opposite the St. Helena project. Eight-inch loop lines are carried from the 12-inch supply main in both the north and south sections of the developed area. The main supply for St. Helena is an 8-inch main carried to about the center of the project. A second supply enters St. Helena at the southeastern corner and loops back into the first. All other mains in both projects are 6-inch. Pressure tests conducted on the project indicate that a fire flow of 1200 to 1500 gallons can be obtained with pressure of 30 pounds in St. Helena and 40 to 50 pounds in Dundalk.

Savannah, Ga. The site of the housing development lies 7 miles up the Savannah River from Savannah and is adjacent to Port Wentworth, a small, recently developed community. The project was abandoned after the signing of the armistice and prior to active construction.

The water supply was to be obtained from a driven well on the property of the Terry Shipbuilding Corporation. The distribution system as designed provided for an 8-inch main, which was to enter the central diagonal street and a second 8-inch line which was to enter the project at the southeast corner. All other mains were to be 6-inch.

The distribution system was designed for fire flows of 750 gallons per minute, in addition to the domestic consumption with a pressure at the hydrants of about 30 pounds. With direct pressure, a flow of 750 gallons could have been obtained at a pressure of 78 pounds and a flow of 500 gallons per minute at a pressure of 90 pounds.

South Jacksonville, Fla. This project is located immediately south of the improved area of South Jacksonville. Water supply is taken from the existing municipal plant, which had to be enlarged to

furnish an adequate supply. The city drilled a new 8-inch well, which afforded a flow of about 1000 gallons per minute, installed duplicate motor driven centrifugal pumps, of 750 gallons per minute each, changed their existing triplex pumps to motor drive, and constructed a new 95,000 gallon concrete reservoir and aeration basin. No treatment is given the water, as it is obtained from wells dug about 1000 feet deep, through sand.

Water is delivered to the project by a 12-inch force main nearly ½ mile long. This main divides at the project, figure 7, into

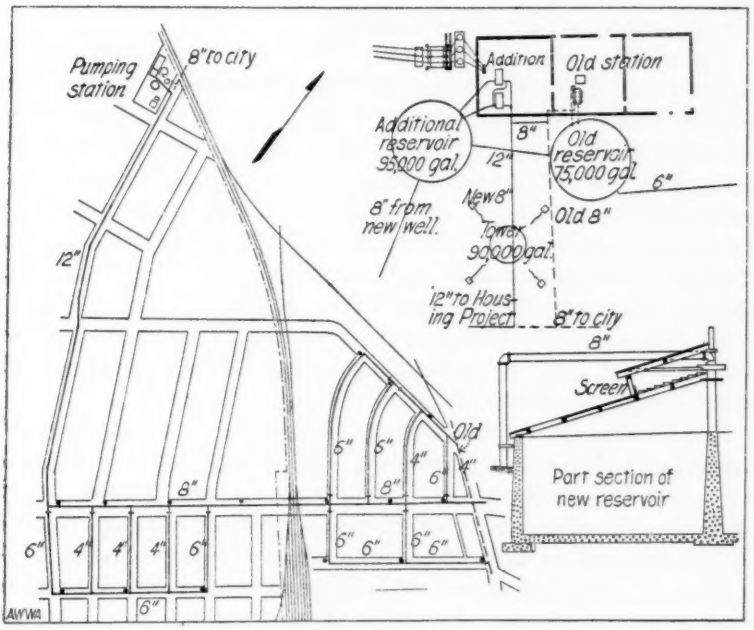

FIG. 7. DISTRIBUTION SYSTEM, SOUTH JACKSONVILLE, FLA.

a 6-inch and an 8-inch, which is carried across the center of the project. Six-inch loop lines are provided throughout and are cross-connected by 4-inch mains where it was not necessary to install hydrants. The system is designed for fire flows of 1500 gallons per minute at pressures ranging from 50 to 60 pounds at the hydrant, with pressures at the pump of 100 pounds.

Lorain, Ohio. This project is located in the northwestern section of the city, on the outskirts of the present built up area. The water supply is obtained from the city.

The distribution system was connected with a 12-inch cast-iron main previously laid to the northwesterly corner of the project and partially along the western border. This latter main was extended along the western and southern borders, where reduction was made to smaller sizes. Another 12-inch main was extended across the north of the project, with an extension into the central portion. Intermediate mains between the northern and southern portions are 6-inch.

The system is designed for fire flows of 1500 gallons per minute, under pressures of 45 pounds at the hydrant, when the pressure at the city pumping station is 90 pounds.

Wyandotte, Mich. The project is located in the southern section of the city. Water is furnished through extensions of the municipal system, which had previously been laid in the eastern boundary of the project. The mains in this section of the city are small and the pressure at the development is not entirely satisfactory. The entire distribution system consists of 6-inch pipe. The system will deliver 1000 gallons per minute at 30 to 35 pounds pressure and 1500 gallons can be secured at pressures of 25 to 30 pounds. Fire fighting equipment will be used at this project.

Manitowoc, Wis. This project is located north of the built-up section of the city, in the direction of residential expansion. The water supply is taken from the city.

The distribution system adjacent to the project is small and the available pressures were insufficient. A short section of 8-inch main was, therefore, laid in the distribution system, exterior to the project. All other mains are 6-inch. Hydrant spacing was held to 300 feet and on account of the very low pressure available, the system was so gated that a shut-off would not cut more than one hydrant out of service. Fire flows of 1500 gallons per minute can be obtained only under hydrant pressure of 20 pounds, and it is therefore necessary to use fire pumping equipment.

CONCLUSION

It is felt that the basic principles which guided the installation of the various water systems, especially the sizes of mains, arrangement of valves and the spacing of hydrants, will do much to raise the standards of construction in the neighborhood of the various projects, thereby resulting in a decreased fire hazard and in securing

better service to the communities. In many cases great patience was necessary and carefully conducted negotiations were required, before some of the municipalities or private water companies could see the necessity of following the standards promulgated by the government. It is, however, pleasing to report, that, after thorough discussion, the officials of these municipalities and private companies agreed to and approved the requirements.

THE MAGNITUDE OF THE AMERICAN MUNICIPAL WATER SUPPLY BUSINESS[1]

By John M. Goodell[2]

Every water works superintendent knows that he is in charg of a plant representing a large investment, but it is doubtful if, in the daily demands for attention to a multitude of details, often small, he holds fast to his realization of the importance of the business he administers. It is the most important of all the public utilities and there is no branch of municipal affairs which surpasses it in intimate relations with the welfare of the community. It is so vital to the daily life of the city that the time has come when the public which owns the water works ought to be brought to a realization of the responsibilities it entrusts to its water works officials and shown the folly of denying to them the compensation and other advantages of men performing like work for private water companies and for other privately owned utilities.

Definite facts regarding the growth of the water supply business are difficult to obtain, especially in the case of the small cities, and even when obtained there is much uncertainty about the extent to which they are comparable. The United States Bureau of the Census collects statistics annually from all cities having a population of 30,000 or more. These are financial statistics and the last that have been made public are for the year ending June 30, 1918. This annual census is made under a special appropriation in which the work is limited to financial data and to cities of the size stated. The 1918 report is restricted, therefore, to the 227 cities of this class. The great number of small water works, public and private, cannot

[1] In the Journal of September, 1919, page 582, President Davis called attention to the desirability of collecting the more important data relating to water works in the United States through the cooperation of the Bureau of the Census. This article has been prepared to show the extent and nature of the information which the Bureau is now collecting under the restricted authority given to it by Congress for the work, and also to indicate some of the difficulties of such work.

[2] Editor, American Water Works Association.

be estimated with any accuracy, but from all the sources of information available to the author it seems probable that there are between 7500 and 8000 works either publicly or privately owned which carry on a regular water supply business. In addition there is a considerable number of industrial plants which supply water to private consumers in their vicinity, sometimes without charge and sometimes at a small flat rate; occasionally these industrial supplies are quite large and there is a distinct question whether they should be regarded as public water supplies or as part of the housing and employment activities of the companies operating them.

One of the difficulties which confront an investigator of the extent of our American water supply business at the outset of his studies is the impracticability of obtaining any complete statistics from all cities at the present time, owing to private ownership of works in from one-fifth to one-fourth of our cities. The private companies do not report to the Bureau of the Census nor are their figures reported in detail to public utility commissions in many of the States. The desirability of obtaining more complete information from both private and public water utilities is recognized by the Bureau of the Census, but it can no nothing without authorization by Congress and Congress is not inclined to give such an authorization at present. Consequently the best that can be done now is to see what the figures which the Bureau is permitted to gather indicate regarding the magnitude of the water supply business. Fortunately all these indications will be under the truth, since the data on which they are based lack figures of the financial operations of private companies.

On January 1, 1918, there were 227 American cities having a population of 30,000 or more. The increase in the number of such cities in the United States has been remarkable. At the time of the first census, 1790, there was just one such city in the country, New York, which barely qualified with its 33,131 inhabitants, not so many as there are in Tulsa, Okla., today. Furthermore, there was little need of such community life as we find today, for a large part of the population was engaged in rural pursuits and our industries were in their babyhood.

By 1850 there were 19 cities having a population of 30,000 or more, and they sheltered 7.3 per cent of the country's whole population. In spite of the effects of the civil war, and perhaps due in a measure to some of the conditions of that period, there was little checking

of the relative increase in importance of such cities, for in 1870 there were 44 of them, with 13.5 per cent of the country's population. In 1890 there were 103 such cities with 20 per cent of the country's people living in them and in 1910 there were 184 with 29.7 per cent of the total population of the nation. The later growth is even more significant; in 1915 there were were 204 such cities, in 1917 there were 219 and in 1918 there were 227, with 32.9 per cent of the nation's population living in them. In other words considerably more than one-third of the entire population of the United States is dependent for its existence in decency, to say nothing of comfort, upon the utilities managed by our American water works superintendents, in places large enough to come within this special census class, which is certainly much larger today than it was two years ago.

In what follows the 227 cities having a population of 30,000 or more in 1918 will be termed the "census cities." Even in their case it has been impossible for the Bureau of the Census to secure comparable data from many of them, and there are only 146 cities from which complete statistical information has been obtainable. These 146 will hereafter be termed "complete census cities."

Cost of municipal government. Everybody knows that the cost of operating our cities has increased rapidly, but the actual facts are startling and little appreciated. In 1903 it cost $7.91 per capita to run the United States, and in the 146 complete census cities it cost $24.64 per capita of their population to meet their expenses. In 1909 these figures were $9.89 and $30.33 respectively and in 1913 they were $10.15 and $32.46 respectively. Then the World War began, but it did not affect this country materially, so far as municipal and national expenses are concerned, for some time. In 1915 we spent $10.52 per capita for the national expenses and $34.53 for municipal expenses in the complete census cities, and in 1917 we spent $14.70 and $33.26 respectively.

The fact stands out clearly that in times of peace the per capita government costs of our cities have been increasing more rapidly than those of the nation. Between 1903 and 1915 national per-capita costs increased 33 per cent while similar costs in the complete census cities increased 40 per cent. The Bureau of the Census makes a deduction from these figures which reads as follows:

These figures disclose at once the greater relative importance in normal times of the proper administration of city affairs and the necessity of such a system of accounting and reporting as will best assist in securing and maintaining economy and efficiency in city government. The necessity of such accounting and reporting is much more pressing in the case of cities than in that of the nation, owing to the greater relative per capita costs of the cities.

With the 1918 report the effect of the World War becomes apparent, for hereafter our national expenses must be heavy, as in European countries. The per capita expenses of the complete census cities in this year were $34.08, an increase of 2½ per cent over 1917, but the per capita national expenses had increased to $89.16, an increase of 506 per cent, a succinct statement of the financial burden of a great war even upon the victors.

Municipal indebtedness. It has been shown that with the rapid growth of cities there is an increasing expense to each resident in their government. Part of the expenses of a city as of the nation are met by incurring debts in one way or another, and here again there are figures which must be considered when making a study of the part played by water works in our municipal affairs.

In 1903 the per capita indebtedness of the 146 complete census cities was $44.71 and that of the nation was $11.44. In 1915 these figures were $77.86 and $10.95 respectively. In 1903 the ratio of per capita municipal to national indebtedness was 3.9 and in 1915 it was 7.1. In 1916 it was over 8, but then the World War began to change the relations. In 1918 the per capita municipal indebtedness was $80.96 while the similar national figure was $104.59.

In this connection the total figures of indebtedness have some significance upon the relative position of water works among municipal activities, because a considerable part of the funded debt of some cities is for water works. It should be said, therefore, that while the net debt of the 146 cities exceeded the net debt of the nation by only 0.9 per cent in 1903, by 1915 it exceeded the national debt by 106 per cent. During this period the population of these 146 cities increased 38.2 per cent and their net indebtedness increased 140.7 per cent, eight times faster than the national debt.

Difficulties in securing comparable data. The Bureau of the Census has found great difficulty in determining the relative financial condition of different municipal activities on account of the lack of uniformity in accounting and for other reasons which it explains as follows:

Inaccurate statements of governmental costs are found in the reports of all cities with public service enterprises, such as water supply and gas supply systems, in which no account is taken of the value of the public utilities furnished other departments by such systems. These inaccurate statements cannot give rise to statistics that are comparable, any more than can the accounts of institutions and parks in the case of cities in which the labor of inmates of institutions is employed without its value being credited to the institution or charged to parks. The inaccurate statements could be corrected by the Bureau of the Census and the basis laid for comparable statistics in the case of these public service enterprises if the data were available for correct estimates. In the case of a few cities the officials in charge of the water supply systems prepare estimates of the value of water furnished, and such estimates are included in the departmental reports, though not in the comptroller's or treasurer's accounts and reports.

It should be stated in this connection that neither in the case of these estimates nor in that of credits which are included in the accounts of a city comptroller of actual payments by a city for water furnished by the water supply system to other branches of the city government is there any great accuracy or comparability, owing to a lack of a well-accepted basis for assigning values to the water furnished by privately owned and municipally owned water supply systems to the departments and offices. The lack of an accepted basis is apparent in the statistics of all other public utility enterprises operated by cities. This condition will continue to make difficult the preparation of accurate and comparable statements of the cost of water and other utilities furnished by public service enterprises to fire departments and other departments until, as a result of general discussion and investigation of the subject, approximately correct values can be assigned to the utilities furnished.

Other difficulties in the way of comparable statistics of public service enterprises exist by reason of the fact that in the case of many of them the cost of making out bills and collecting revenue is included with the cost of collecting revenue other than of these enterprises, and there is no basis in city accounts for comparing the expenses of a municipally owned enterprise, the employees of which make out and collect all bills for services or commodities furnished, with those of a similar enterprise whose bills are made out and collected by one of the general financial officers of the city. The Bureau of the Census has formulated no method by which it is able to overcome the difficulties here mentioned, and to the extent that the local accounts here described are inaccurate the statistics in which their data are incorporated will fail to be strictly comparable as between the several cities.

With a few exceptions, cities do not include depreciation among their expenses, nor do they make other adequate provision for it in their accounts. As a result, their reports exaggerate their outlays or expenditures for additions to their permanent properties and public improvements and understate their current expenses. These exaggerations and understatements can not be overcome by the Bureau of the Census in its efforts to compile accurate statistics of government costs.

Many of the public improvements of cities require several years for their completion, and the cities receive no benefit from their use until completed.

These improvements are constructed from the proceeds of the sale of bonds on which the cities pay interest during the construction period. In commercial accounting interest so paid is always charged to the account of outlay or capital expenditure, and interest is charged as a current cost only after the property constructed comes into service. For only those cities which recognize this principle of good commercial accounting is the Bureau of the Census able to present true statements of the costs of public improvements, and to show also the total interest for the use of credit capital.

When the accounts of governments with the value of their properties and public improvements are properly kept, they contain approximately correct statements of their value in use as determined either by their original cost or the cost of their replacement, less depreciation. When, however, these accounts are improperly kept, they do not contain correct statements, and for that reason lose much of their accounting and administrative importance and cannot be taken as a basis for a correct judgment concerning the financial condition of governments or the results of government methods of constructing and financing improvements.

Few cities have trustworthy records of the cost or present value of their properties; a still smaller number have trustworthy records of the original cost of their public improvements or data for estimating the present cost of replacing them, and few prepare any trustworthy estimates of the probable amount to be realized from their uncollected revenues. Some improvement has been made, however, in this branch of accounting during the last few years. Of the factors bringing about this improvement, one of the most potent has been the repeated attempts made by the Bureau of the Census to secure correct information with reference to the value of governmental properties and public improvements. As a result of the progress made in this field of accounting, the statistics of the value of governmental properties are more trustworthy than formerly, although they are still far from perfect. Unfortunately the same statement does not apply to the statistics of public improvements, the publication of which cannot be resumed until such time as the accounts of the cities justify it.

Receipts and payments. The Bureau of the Census draws a distinction between revenue, which will be termed "receipts" in these notes, and non-revenue receipts,which include receipts in error and accrued interest received on the original issue of city debt obligations and will not be considered as part of the "receipts." It also divided payments by municipalities into two classes, governmental-cost payments which comprise all expenditures other than those of the second class, non-governmental-cost payments, or payments in error, payments of accrued interest on investments purchased, and payments for outlays balanced by amounts credited in outlay accounts. The second class will not be considered in these notes.

In 1918 the actual receipts of the 227 cities were $1,096,175,353, and $27,919,546 was paid by transfer. The actual payments

were $1,144,629,589, and $28,066,240 was paid by transfer. The cash in the possession of the cities decreased, therefore, $11,903,928, or 3.8 per cent, leaving a balance on hand on June 30, 1918, of $303,079,588. Of the individual cities, 104 reported an increase in their cash balances and 123 reported a decrease.

These figures have been compiled not only from the accounts of the cities but also from those of other local governmental units covering the same areas, such as school, park, sanitary and water districts, and from the accounts of counties where they collect revenue for municipal purposes. The importance of these statistics is stated as follows by the Bureau:

> Comparisons between revenue receipts and governmental-cost payments are of the greatest significance in municipal finance. If a city is realizing more money from revenue than it is paying for expenses, interest and outlays, it has a balance which may be applied to reducing indebtedness; while if its payments for expenses, interest and outlays are greater than its revenue receipts, the city is increasing its indebtedness. If it is realizing from revenues enough money to pay its expenses and interest, but only a portion of its outlays, it is imposing upon the future a part of the burden of paying for its permanent properties and public improvements. Of the 227 cities covered by this report, 80 realized enough from revenues to meet all their payments for expenses, interest and outlays, and to have a balance available for paying debt. The excess of revenue receipts of these 80 cities over their governmental-cost payments amounted to $22,323,060. New York, N. Y., reported the greatest excess, $4,537,419. The excess of governmental-cost payments over revenue receipts by the 147 cities reporting such excess was $70,923,990. This excess varied from $12,578,980 for Philadelphia, Pa., to $2309 for Quincy, Mass. The net excess of the governmental-cost payments of the 227 municipalities over their revenue receipts was $48,600,930.

Table 1 gives the main facts regarding the changes which have been taking place in the last fifteen years in the per capita revenue receipts and governmental-cost payments for which complete statistics have been obtained. It will be observed that the expenditures for both classes of payments increased about in the same ratio, and that the World War exercised a distinct effect on them, which we all knew to be the case although its definite amount has not previously been recorded. The definitions of the various classes of receipts and payments adopted by the Bureau of the Census in classifying the data summarized in the table are as follows:

> *Expenses of general departments.* Under this heading are tabulated all payments for municipal expenses other than those for the operation and maintenance of public service enterprises.

Expenses of public service enterprises. Under this general head are included the expenses of operating and maintaining water supply and gas supply systems, electric light and power systems, markets, and all other enterprises operated and maintained to supply the inhabitants with public utilities or services.

Municipal outlays. Municipal outlays are the costs of properties, including land, buildings and equipment, and public improvements more or less permanent in character, which are acquired or constructed by municipalities for use in the exercise of their municipal functions or in connection with the business enterprises undertaken by them.

TABLE 1

Summary of per capita net revenue receipts and net governmental-cost payments for specified years in 146 cities

YEAR	PER CAPITA NET REVENUE RECEIPTS			PER CAPITA NET GOVERMENTAL-COST PAYMENTS				
	Total	Other than of public service enterprises	Of public service enterprises	Total	For expenses of general departments	For expenses of public service enterprises	For interest	For outlays
1918	$32.76	$29.41	$3.35	$34.08	$20.64	$1.59	$3.78	$8.07
1917	31.97	28.84	3.13	33.26	19.53	1.39	3.66	8.68
1915	30.00	26.97	3.03	34.53	18.95	1.39	3.58	10.60
1913	28.55	25.74	2.81	32.46	17.67	1.35	3.15	10.29
1911	28.07	25.09	2.98	32.25	16.91	1.26	3.07	11.02
1909	26.42	23.53	2.89	30.33	16.06	1.22	2.86	10.18
1907	24.67	21.90	2.77	29.91	15.84	1.17	2.56	10.34
1905	22.79	20.19	2.60	25.57	13.81	1.07	2.36	8.32
1903	21.14	18.71	2.42	24.64	13.25	1.10	2.06	8.23

In this table there is found one of the first indications of the importance of such statistics to the water works man. It will be observed that in 1903 53.8 per cent of the payments for governmental costs were for the expenses of general departments, 4.5 per cent for expenses of public service enterprises, 8.4 per cent were for interest and 33.4 per cent for outlays. The corresponding percentages for 1918 were 60.6, 4.7, 11.1 and 23.7. In other words the cities have kept on spending just about the same percentage of their total payments for all purposes, on their public utilities in which group water works form the major element. It is of interest to learn, also, from other data collected by the Bureau of the Census that the public utilities owned by the cities have been earning just about the same percentage of the total revenue receipts during the same period, running from a minimum of 9.9 per cent of the total in 1917 to 11.5 per cent in 1903. In 1918 it was 10.2 per cent.

The receipts from public service enterprises in 1918 in the 227 cities were $116,494,645 in all. The various classes of enterprises and their contribution to this total were: Water works, $90,139,705; electric light and power systems, $8,315,960; gas supply systems, $1,418,511; markets and public scales, $1,758,480; docks, wharves and landings, $7,786,509; cemeteries and crematories, $1,049,706; public halls, $172,862; subways for pipes and wires, $311,555; ferries, $1,729,491; toll bridges, $443,874; city farms, $50,798; miscellaneous, $3,317,194. The largest single contribution to the miscellaneous receipts was the municipal railway of San Francisco, which paid in $2,392,236.

During this year the total receipts of the 227 cities were $1,124,094,899. Of this amount $705,723,158 came from the general property tax, then the $90,139,705 from water works, with special assessments third with a contribution of $72,673,785.

Attention is again called to the fact that these figures are more or less misleading, because, in order to form a complete picture of the water supply business in our cities of 30,000 or more population we must add to the figures of the Bureau of the Census the data which can only be obtained from the private water companies operating in them. San Francisco is put down as owning and operating a municipal water works, for example, which is manifestly the fire-protection system operated under high pressure, while the greatly larger works of the Spring Valley Water Company are not recognized. It is impossible to be critical, however, when the Bureau frankly acknowledges the incompleteness of the data it presents and states the reasons, already quoted, for its inability to present more comprehensive figures.

Growth of water supply. In Table 2 is given a summary of the revenue receipts and payments for expenses and outlays of water works in the 146 complete census cities. It will be seen that from 1903 to 1918 inclusive the revenues increased 90.5 per cent and the expenses increased 104.8 per cent. The expenses were 40.6 per cent of the receipts in 1903 and 43.6 per cent in 1918.

The governmental-cost payments for expenses of public service enterprises in 1918 amounted to a total of $55,174,480 in the 227 census cities, of which amount $39,699,280 was spent on water works operation and maintenance, $5,050,679 on the operation and maintenance of electric light and power plants, $1,115,947 on the gas supply systems, $735,081 on markets and public scales, $2,716,738 on

docks, wharves and landings, $1,232,974 on cemeteries and crematories, $362,203 of public halls, $11,733 on subways, and $4,249,845 on all other enterprises, the largest item in the last group being $1,476,288 for the operation of the municipal railway of San Francisco.

The property owned by the water works of the 227 cities in 1918 was valued at $1,205,377,311, or practically the same amount that the park and other recreation features of our cities are now estimated to be worth. No other branch of municipal activities even approaches the value of these two groups. The valuation of school property, often considered the most valuable asset of a city, is only two-thirds as large as the average valuation of the water system or the recreation facilities of a city.

TABLE 2

Growth of water supply revenues, payments and outlays in 146 cities during the period 1903–1918

YEAR	REVENUE RECEIPTS	PAYMENTS		
		Total	Expenses	Outlays
1918	$81,884,234	$66,007,480	$35,745,424	$30,262,056
1917	76,964,015	63,918,158	31,885,640	32,032,518
1915	70,599,902	76,609,355	30,217,904	46,391,451
1913	65,317,823	91,276,498	29,227,070	62,049,428
1911	63,610,139	91,968,532	25,882,798	66,085,734
1909	57,105,840	76,452,815	23,519,487	52,933,328
1907	52,712,870	61,760,318	20,827,844	40,932,474
1905	47,396,604	41,581,743	18,677,311	22,904,432
1903	42,986,187	*	17,449,061	*

* Outlays for water supply systems not reported separately.

The funded debt of the water systems in 1918 was $586,555,069, or 48.7 per cent of the valuation. In ten cities the outstanding debt for water supply was in excess of its valuation, which may have been due to the fact that while a heavy bonded indebtedness may have been incurred for new works, the latter were unfinished and consequently had not been valued at their ultimate worth.

SOCIETY AFFAIRS

MINNESOTA SECTION

The Section held a meeting at Rochester, Minn., on December 5 and 6. The program was as follows:

"The City of Rochester and its Water Supply," M. G. Holmes.

"Water, Water Everywhere," Dr. W. F. Bleifuss.

"Some Changes in the Policy of the American Water Works Association," F. W. Cappelen.

"The Necessity of Laboratory Control in Water Purification," L. I. Birdsall.

"Defects in the Construction of Underground Water Supplies," J. A. Childs.

"Water Supplies and their Relation to Goiter," Dr. H. S. Plummer.

"Water Works Accounting," Wm. R. Young.

"Water Rates," H. F. Blomquist.

"Complaints from Water Users," D. A. Reed.

The Hill Cup, awarded annually to the Section showing the largest percentage of gain in membership, was won three times consecutively by the Minnesota Section, and thus became its property permanently. The last award was during the troubles of war times, when the Association suffered a net loss in membership, and the Minnesota Section gained a single member. The Section has accordingly decided not to accept the cup permanently and has asked that the award of last year be eliminated from consideration on account of the abnormal conditions. Hence the Cup will be awarded again this year, and the Sections have another opportunity to compete for it through increasing their membership.

NEW YORK SECTION

A meeting was held at the Park Avenue Hotel, New York, on December 17. The general subject for discussion was subaqueous pipe lines, which was introduced by a paper by Francis H. Sherrerd on a 30-inch line to supply Bayonne, N. J., now under construction.

The method of laying a 36-inch line across the Narrows to supply Staten Island was described by Col. John P. Hogan, and other work of the same nature was explained by George E. Rodman and Patrick F. Quilty.

Among the questions submitted for discussion was the following: If manufacturers will, as has been suggested, so improve the iron going into pipe and specials that it will have, say, 50 per cent greater strength with as much elasticity as compared with present irons being used, can pipe users afford to eliminate all but two classes of pipe and fittings, one class for pressures now in use for the so-called standard systems, and the other class for use for high pressure fire service systems?

ILLINOIS SECTION

The Section held a meeting at the Chicago Engineers Club on December 10, 1919. A social gathering held from 4 to 6 p.m. was followed by a dinner at the Club rooms. After dinner Edward Bartow, formerly Lieutenant Colonel, gave an illustrated paper on "Water Supply Services of the American Expeditionary Forces," and L. A. Fritze, formerly Captain, gave an illustrated paper on "The Water Supply Problems in a Combat Division." In the absence of W. E. Lautz, Chairman of the Section, F. C. Amsbary, Vice Chairman, presided. Forty persons attended the meeting.

It was the purpose of Mr. Fritze in preparing his paper that effort should be made to have legislation enacted to provide in the permanent organization of the army a corps of experts with experience in the construction and operation of waterworks. Mr. Amsbary appointed the following to prepare a resolution: Dabney H. Maury, W. W. DeBerard and G. C. Habermeyer.

The following resolution was prepared and adopted:

WHEREAS, During the recent war with Germany the efforts of specialists in water supply work resulted in furnishing to our troops in this country and abroad water supplies which in quantity and quality were better than those ever before provided under similar conditions; and

WHEREAS, It is essential that in case of any future similar emergency, our Army should be prepared to deal with the vitally important matter of water supply with the minimum of delay and in the most efficient manner possible:

Resolved, That it is the unanimous opinion of the members of this Convention that the permanent organization of the Army should include a water supply service whose personnel should consist of officers and men of especial skill and experience in the design, construction and operation of water works,

and of sanitary engineers, bacteriologists and chemists, who have made a specialty of taking care of the quality of water supplies;

Resolved Further, That in addition to a permanent skeleton organization, the water supply service should include a reserve corps from which there can be mobilized in the shortest possible time, men of such experience and attainments as would qualify them to be given responsible charge of providing adequate and safe water supplies for our troops, wherever stationed, from the training camps to the first line trenches;

Resolved Further, That the Secretary be instructed to send a copy of these resolutions to the Senators and Representatives from the State of Illinois, to the Secretary of War, and to all members of the American Water Works Association residing in Illinois.

ADDITIONS TO THE MEMBERSHIP

Active Members

William G. Bank, Assistant Engineer, Bureau of Water, Newark, N. J.; Oak Ridge, N. J.

Lawrence Cox, Consulting Engineer, Webster City, Iowa.

Edwin Wesley Hess, Consulting Engineer, Clearfield, Pa.

Albert G. Roech, Assistant Hydraulic Engineer, Montclair Water Company, Paterson, N. J.

Harry N. Roberts, Jr., Civil and Sanitary Engineer, Longview, Texas.

Frederick G. Scherer, Assistant Engineer, Bureau of Water, Newark, N. J.

Burr M. Stark, Civil Engineer, Amsterdam, N. Y.

Ronald W. Starr, Orillia, Ont.

Corporate Member

Water Department, Borough of Haledon, N. J.

Associate Members

Cutler-Hammer Manufacturing Company, New York, N. Y.

Keystone Iron & Steel Works, Los Angeles, Calif.

The Refinite Company, Omaha, Neb.